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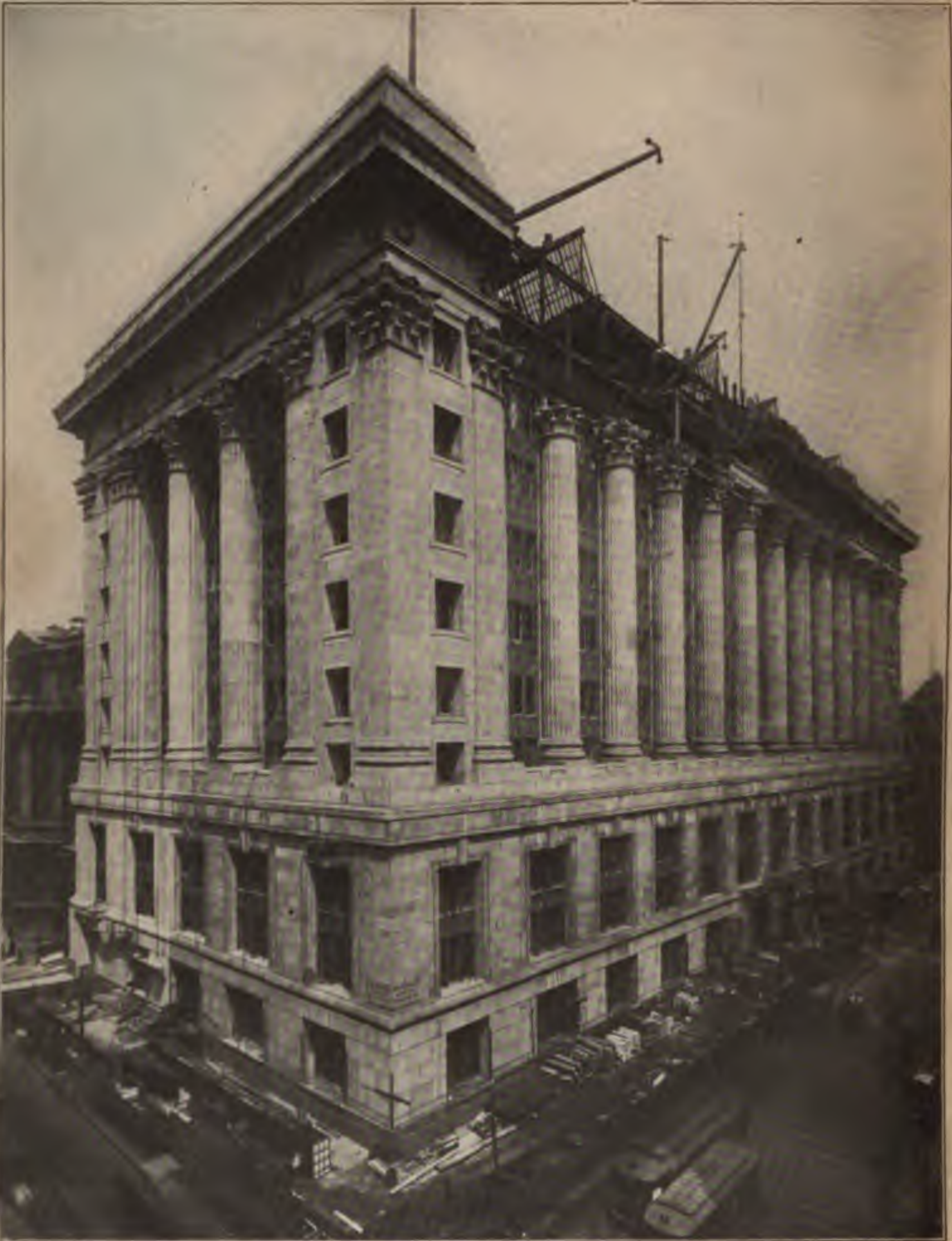

COOK COUNTY BUILDING, CHICAGO, ILL.

Holabird & Roche, Architects, Chicago, Ill.

Building Completed in 1907. Cost, $5,000,000. Length, 380 ft.; Width, 160 ft.; Height, 204 ft. Eleven Stories, with Sub-Basement Connecting with Tunnel System and Electric Railroad Service Underlying Business Portions of City. Walls, Gray Vermont Granite; Spandrel Sections, Green Terra-Cotta. The Corinthian Columns on the Exterior are 94 ft. Long and 9 ft. in Diameter. General Interior Plan is that of Letter E. Building Contains its Own Electric-Light and Steam-Heating Plants. City Hall, Shown at Left, is Practically a Duplicate of the Old County Building Replaced by this New Structure, and will Itself be Replaced by a Similar Building. Photographed June, 1907, 17 Months after Excavation was Started.

Building Superintendence

X

A Working Guide to the

REQUIREMENTS OF MODERN AMERICAN BUILDING PRACTICE AND THE
SYSTEMATIC SUPERVISION OF BUILDING OPERATIONS

By EDWARD NICHOLS
Architect, Boston, Mass.

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Foreword

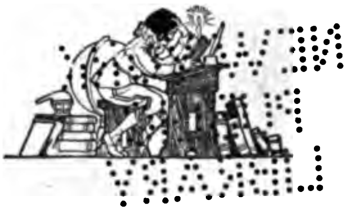
IN recent years, such marvelous advances have been made in the engineering and scientific fields, and so rapid has been the evolution of mechanical and constructive processes and methods, that a distinct need has been created for a series of *practical working guides*, of convenient size and low cost, embodying the accumulated results of experience and the most approved modern practice along a great variety of lines. To fill this acknowledged need, is the special purpose of the series of handbooks to which this volume belongs.

¶ In the preparation of this series, it has been the aim of the publishers to lay special stress on the *practical* side of each subject, as distinguished from mere theoretical or academic discussion. Each volume is written by a well-known expert of acknowledged authority in his special line, and is based on a most careful study of practical needs and up-to-date methods as developed under the conditions of actual practice in the field, the shop, the mill, the power house, the drafting room, the engine room, etc.

¶ These volumes are especially adapted for purposes of self-instruction and home study. The utmost care has been used to bring the treatment of each subject within the range of the common understanding, so that the work will appeal not only to the technically trained expert, but also to the beginner and the self-taught practical man who wishes to keep abreast of modern progress. The language is simple and clear; heavy technical terms and the formulæ of the higher mathematics have been avoided, yet without sacrificing any of the requirements of practical instruction; the arrangement of matter is such as to carry the reader along by easy steps to complete mastery of each subject; frequent examples for practice are given, to enable the reader to test his knowledge and make it a permanent possession; and the illustrations are selected with the greatest care to supplement and make clear the references in the text.

¶ The method adopted in the preparation of these volumes is that which the American School of Correspondence has developed and employed so successfully for many years. It is not an experiment, but has stood the severest of all tests—that of practical use—which has demonstrated it to be the best method yet devised for the education of the busy working man.

¶ For purposes of ready reference and timely information when needed, it is believed that this series of handbooks will be found to meet every requirement.



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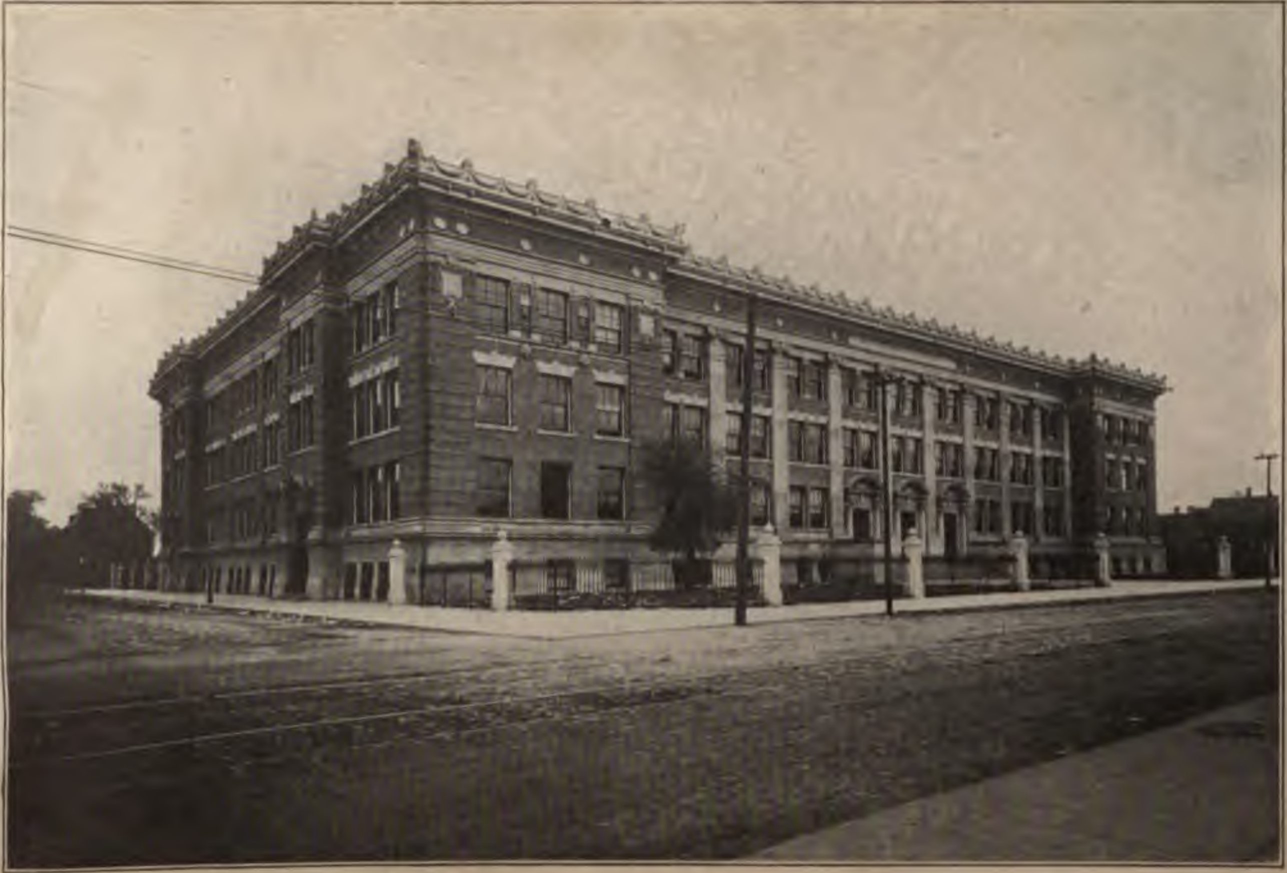


WENDELL PHILLIPS HIGH SCHOOL, CHICAGO, ILL.

Wm. B. Mundie, Architect.

Built in 1904. Cost, $300,000. Note the Use of Ionic Pilasters.

BUILDING SUPERINTENDENCE

PART I.

INTRODUCTION.

The superintendence of building operations is one of the most important, and at times one of the most perplexing duties which an architect is called upon to perform. Plans may have been prepared with the greatest of skill and elaboration, and details may have been worked out to a marvel of perfection; and yet by the want of attention given at the proper time, costly mistakes may be made and results attained which are a source of annoyance and expense to the owner, and often a lasting discredit to both architect and builder. It is only by constant watchfulness and by the exercise of a thorough knowledge of common practices and materials, that these errors can be avoided, and it is the duty of the architect, as superintendent, and a just and impartial referee between the owner and the builder, to acquire this knowledge and to exercise it freely and decisively.

The owner, who has secured the services of an architect, will naturally expect from him something more than the builder could have furnished. Superiority in matters of taste he will expect as a matter of course, and beyond this a superior knowledge of materials and construction; and an executive ability to handle men and direct the many forces which must be applied to obtain a certain and satisfactory result. The architect should possess then, as superintendent, a thorough knowledge of the materials at his disposal and should see clearly before him, in his mind's eye, the building which he proposes to erect. To do this, he must know how all the various elements of the building are to be assembled and moulded into a complete whole.

To a familiarity with details must be added such a quickness of perception and soundness of judgment, that it will be impossible for any bad work to escape his notice, and to this knowledge of the general principles of building, he must add an understanding of principles and possibilities far beyond that of the builder, so that he can foresee causes and effects and guard against any waste of effort or of time. In his position of referee, he must show such a familiarity with building matters that his judgment will be respected by both owner and builder; and he must have confidence that his opinions are correct, and having rendered a decision he must stick to it, for if he shows weakness or indecision it will not take long for the workmen to discover it, and he will be discredited and very likely will be imposed upon. It will not do for the architect to trust too much to the generosity of the owner, or to the liberal intentions of the builder; for it is likely to be the case that both are at the same time trusting in the ability of the architect and the clearness of his foresight.

Relations with the Owner and Contractor. It is important to have as early as possible a clear understanding of what is to be expected by the owner, and to have him understand as clearly what is due to him from the architect. The owner, in his implicit confidence and trust in the foresight of the architect, is likely to visit upon him the blame for failures of particular construction, which can only be avoided by the care of superior workmen under the constant watchfulness of the builder or an ever alert clerk-of-the-works; and it is well for the architect to have it understood at the beginning that he cannot always be present and that he cannot in ordinary practice, guarantee perfection of plan or execution, but can agree to exercise reasonable care and observation.

With the contractor it should be clearly understood at the beginning that the work is to be done strictly in accordance with the drawings and specifications, that the materials are to be as called for, the workmen to be competent, and the builder himself interested and capable. If any material appears upon the site which is unfit, it should be rejected at once and finally, for any laxity or indecision upon this point at the start will be sure to be taken advantage of, and will be a precedent for future indifference. Any work not carefully done, or in accordance with drawings must be at once taken down, in the presence of the architect if possible, and any mistakes discovered should be noted before they are forgotten or crowded aside by other details.

Familiarity with Site. Of prime importance to the architect in starting a new building is a familiarity with the site and with local conditions and customs, and it will be of advantage to him to make the greatest possible use of the time usually spent in preliminary visits to the locality, to observe what is being, or has been done in the vicinity. The more familiar the architect is with local customs or possibilities, the more efficient will his supervision of that particular building become, that he may reject practices which are bad and profit by those which are good. There are very few buildings erected from which the young architect cannot learn something, and it is an unprogressive builder who has not some particular method which will be new to the superintendent.

Drawings. Another essential, and one of greatest importance, is that the superintendent should have a perfect understanding of the drawings and specifications. If they have been prepared by the architect who is to superintend the work, an understanding is assured, but even in this case it will be necessary to consult the plans often, lest something be overlooked or confused with some other building which the architect may have in mind. It will also be of service in enabling him to look ahead, and to prevent many unintentional deviations which may cause delay or damage to the construction if once started upon, through carelessness or unfamiliarity on the part of the builder, or of the foreman upon whom will devolve many of the duties and responsibilities of modern building operations.

With the foreman an understanding should be had at once that he is to work *with* the architect, and not *against* him. It is poor policy for the architect to ignore suggestions made by the foreman, for if he is a thorough mechanic of ability and foresight, as the foreman of a building of any importance should be, he will often be in a position to save the owner from needless expense, and the architect from many of the vexatious conditions and minor complications which often arise in ordinary building transactions. The foreman, as well as the master builder himself, should receive personal instruction from the architect, and should be particularly instructed to look the drawings over carefully, and to report to the architect any discrepancies in figuring, or any apparent difficulties of execution which they may discover, as well as any points not clearly shown or fully understood.

Confidence in Decisions. With this feeling of co-operation thoroughly established between the owner, the architect, and the builder, the architect will be in a position to decide any questions of difference with an assurance that his decisions, being fair and impartial, will be respected, and being satisfied that his opinions are correct, he should announce his decisions promptly and impartially, and his answer being once given he must have the courage to maintain his position unless he be proved to be in the wrong. A lack of confidence in his own judgment, or indecision may affect the prestige of the architect, and might be taken advantage of.

Systematic Plan of Supervision. In following the construction of a building the superintendent will find it of importance that some systematic method shall be followed in order to insure that attention is given to the various details of construction at the proper time. If this is not done many defects of construction and workmanship are liable to be concealed or built upon in such a way as to make the remedy impossible or at the least inconvenient. To guard against this, the superintendent should make a point of going all over the building at each visit and examining carefully any work which has been done since his last visit. In this way he will not only guard against concealed defects but he will be able to time his next visit so that special operations, which he will be able to foresee, will receive his personal attention and direction at the proper time.

Rejection of Materials. One of the most important safeguards against defective building is the careful inspection of the materials as they are delivered at the building site, and the prompt rejection of any improper materials at that time. These should be marked plainly, in such a way that it will be impossible to use them in the superintendent's absence without the mark being seen. If poor materials have been brought into the building, they should be rejected at once, and if possible removed from the building site. If the contractor finds at the start that all poor materials will be surely rejected, and that all work which is not properly done must surely be rebuilt, he will be careful that both workmanship and materials are kept up to the proper standard, and will keep on the building only workmen who prefer to do a good job rather than a bad one; for his own sake as well as for the good of the building.

Theory. These preliminary remarks upon the duties and responsibilities of the superintendent, will serve to bring before the student of Architecture the importance of a familiar knowledge of ordinary practice. The young architect or student will rarely have an opportunity of gaining this knowledge by practical experience, and it will be necessary for him to depend in a great measure upon technical books for the knowledge which he must possess. It will be the object of this paper to point out to the student some of the ordinary operations of building construction, rather than the theoretically perfect methods, in a manner that can be easily understood, and to show as well some of the ways in which defective work and materials are to be discovered and avoided.

It will be assumed that the student has become familiar with the usual methods of drawing and construction from his previous work and that he would be able, if called upon, to superintend the construction of the suburban house which has been used as a type. By this it is not to be understood that the construction of a dwelling is the easiest matter, for this is not the case, but it is chosen because there is greater opportunity for the comparison of results with practice, in the buildings which we live in, and it is also this class of building which contains a variety of structural problems.

Selection of Site. First in importance to the owner as well as to the architect is the selection of the spot where the house is to stand. To the owner the main essential will be the outlook and convenience of approach, and at the same time the appearance which the house will present from the various approaches, with the maximum of the light and warmth of sunshine in the principal rooms, that the situation will allow. In almost all portions of our country a southern or eastern exposure is the pleasantest, and should be the choice for the principal rooms which will thus receive the morning sunshine and warmth in winter, and will avoid the intense heat of the afternoon sun in summer.

To the architect, less apparent, but no less important considerations present themselves in the practical aspects of the ground. In rocky or hilly country, besides the importance of outlook, is the importance of placing the house so that natural advantages of slope and ledge may be taken advantage of for driveways or yards; and in every location is the consideration of the character of the soil.

Soil. The soil may be rocky, or clayey, or sandy; it may be springy or well drained. The surest way to find out the actual condition, is by digging test pits to the proposed depth of the cellar, but in many cases the appearance of the surface will give sufficient indication of the nature of the soil, while the presence of ledge may be detected by driving a rod into the ground to the depth of excavation. If rocky or clayey, we may anticipate trouble from water, which in rock or clay finds a way into the excavations made (Fig. 1) and, having no way of escape, gradually rises until the pressure is sufficient to force a way through the cellar wall or concrete in spite of almost any precaution which may be taken to exclude it. The only remedy is to give the water an easier way to escape than through the wall or cellar concreting; and in towns where there are sewers, this is an easy matter, as it is only necessary to secure a good connection with the sewer by means of suitable pipes, which must be started at a level lower than the cellar bottom. (Fig. 2). This will require that the house be set high enough to bring the bottom of the cellar well above the top of the sewer. If the house is in a locality where there is no sewer, a similar result can be obtained by laying drains running with a proper grade from the cellar of the house to wherever an outlet can be found at a lower level. This can usually be done in a rolling country, but a cellar in clay or rock in a level country is likely to be a continual source of trouble and should be avoided if possible. Most house-lots in the suburban towns will afford some choice in location, so that often serious trouble may be avoided by a careful examination of the soil and of surrounding conditions. In sandy or gravelly soil

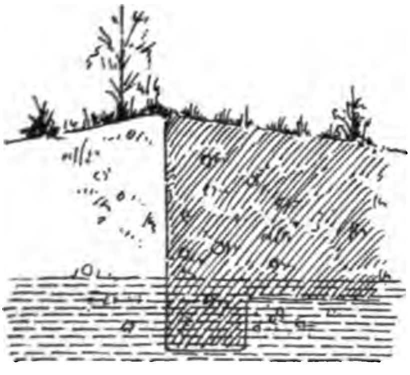


Fig. 1. Ground Water.

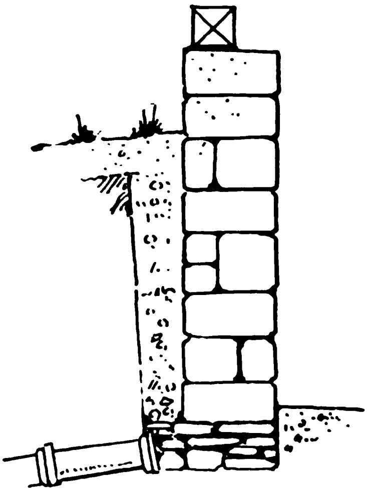
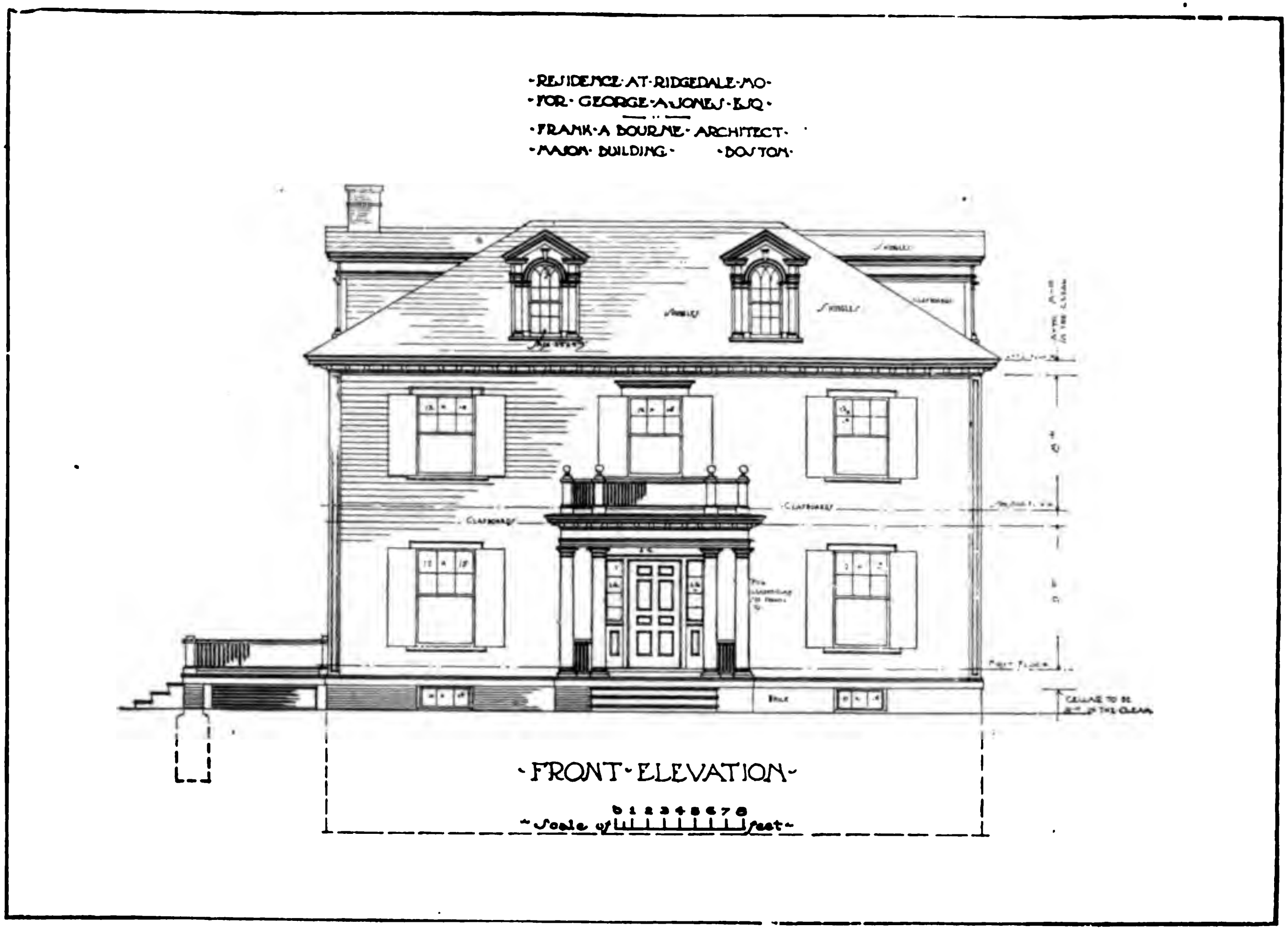


Fig. 2. Cellar Drain.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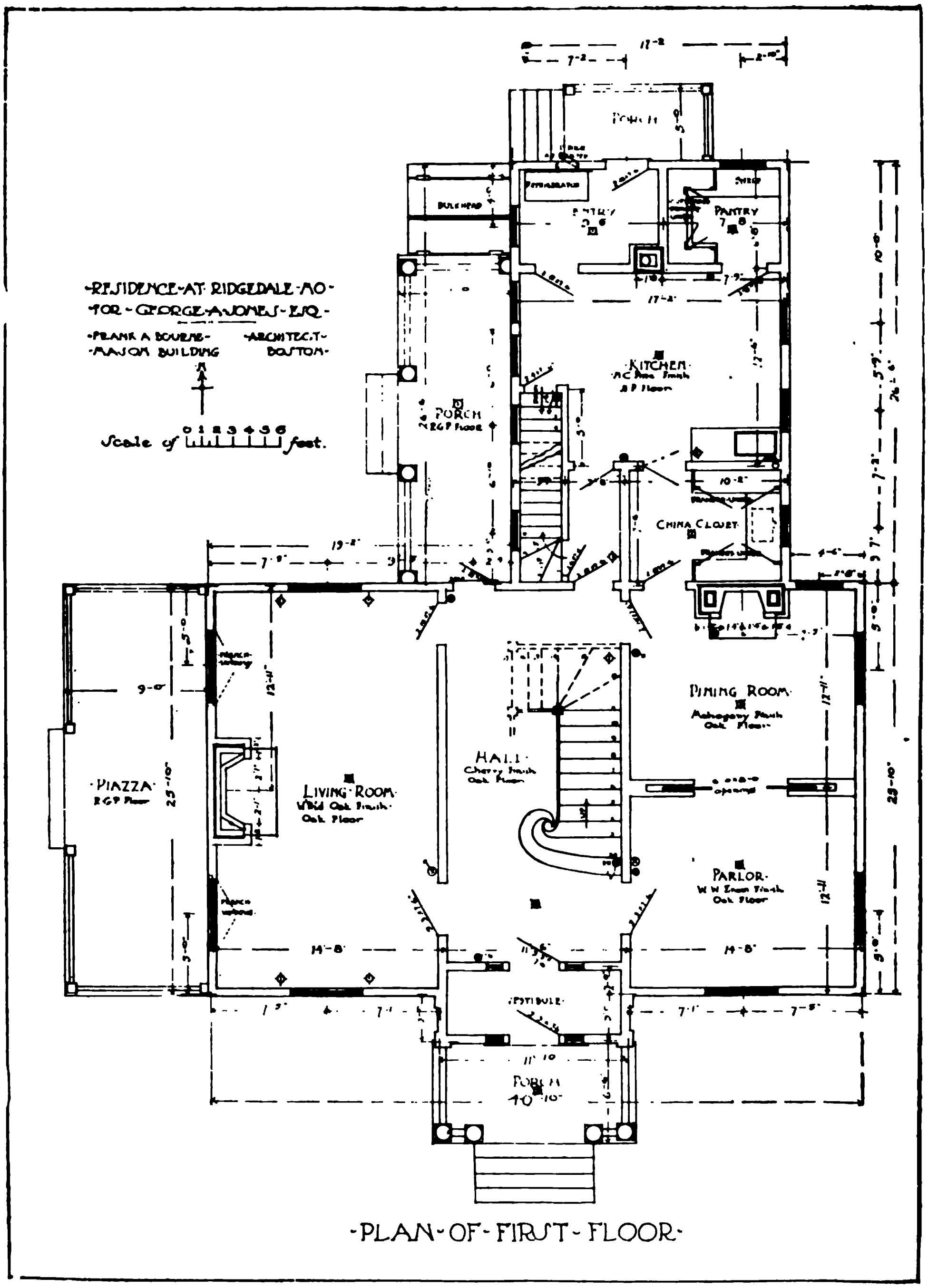
·FOR·GEORGE·A·JONES·ESQ·
·FRANK·A·BOURNE·ARCHITECT·
·MASON·BUILDING· ·BOSTON·
Shingles
Shingles
Shingles
Clapboards
Clapboards
Clapboards
First Floor
Brick
·FRONT·ELEVATION·
0 1 2 3 4 5 6 7 8
·Scale of feet·

Fig. 3.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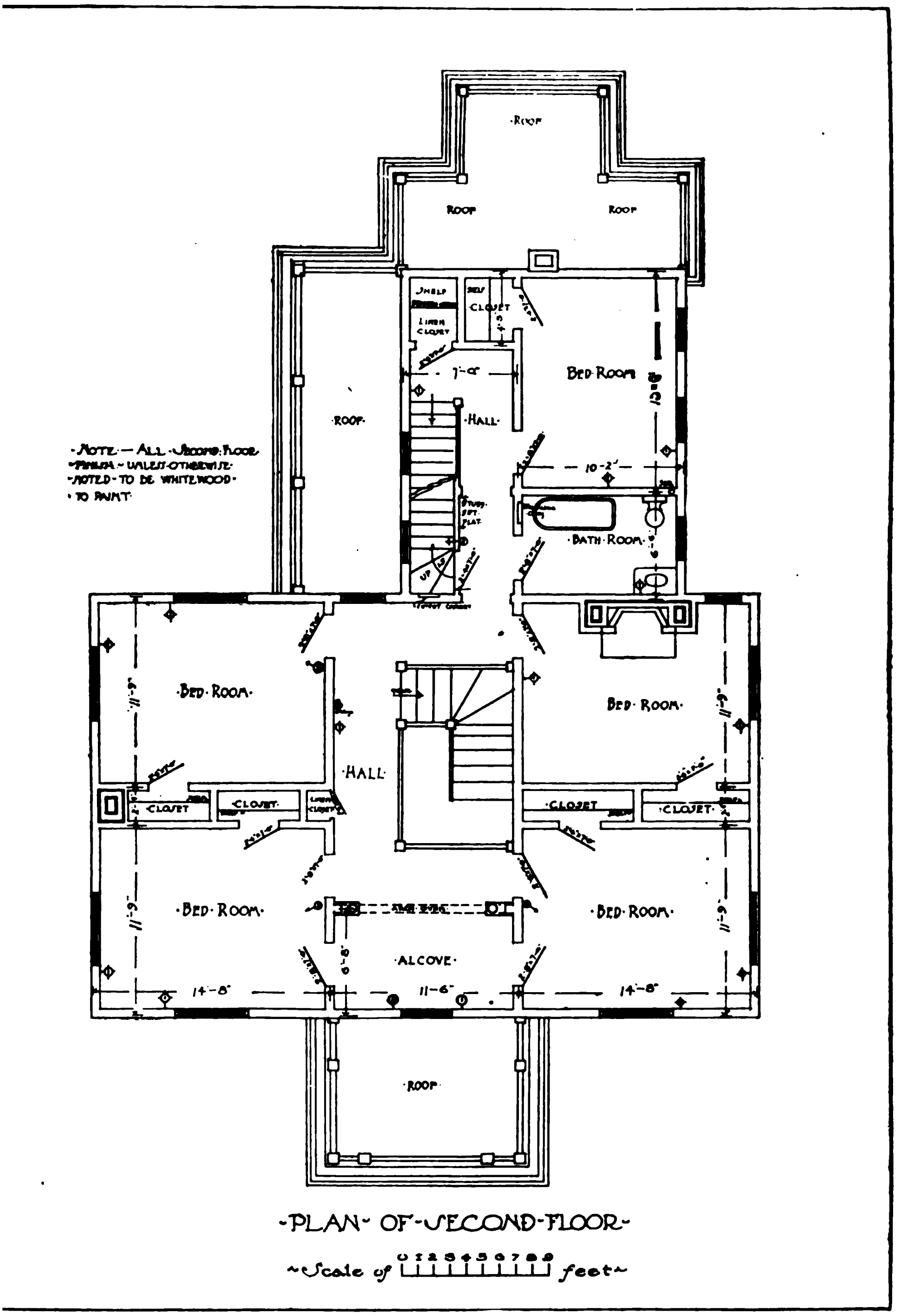
HALL
DINING ROOM
PARLOR
VESTIBULE
PORCH
PLAN OF FIRST FLOOR

Fig. 4.


ROOF
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10'-2"
BATH ROOM
·NOTE — ALL SECOND FLOOR
·FINISH – UNLESS OTHERWISE·
·NOTED · TO BE WHITEWOOD·
· TO PAINT·
BED ROOM
11'-9"
HALL
BED ROOM
11'-9"
CLOSET
CLOSET
LINEN CLOSET
CLOSET
CLOSET
BED ROOM
11'-9"
BED ROOM
11'-9"
ALCOVE
14'-8"
11'-6"
14'-8"
ROOF
·PLAN· OF·SECOND·FLOOR·
~Scale of 0 1 2 3 4 5 6 7 8 9 feet~

Fig. 5.

hardly any extra precautions will be needed as the water is free to drain away through the sand and will have no tendency to run through the wall of the cellar. Even in sandy soil, however, it will be well to give the outside of the wall a coating of cement or asphaltum, taking care to see that the whole surface is covered.

Description of House. The house which we will assume to construct is already familiar to the student in detail, and we may suppose it to be erected upon a suburban lot not wholly level but with the usual variations of ground and aspect. The house is designed in the Colonial style (Fig. 3), and comprises a large living-room, hall, parlor, dining-room, back-hall, china closet, kitchen, pantry and entry, on the first floor (Fig. 4); and five chambers and bath room with stair halls on the second floor (Fig. 5). The attic is unfinished, and the basement will contain a laundry with wash trays, a store room and servant's water closet. The living room is finished in quartered oak, the dining-room in mahogany, the parlor, hall and sleeping rooms in white painted finish. The kitchen and service portions of the house are finished in North Carolina hard pine.

The floors of main house will be of quartered oak in the first story and spruce in the second story. The floors of the service portions will be of Georgia pine. The exterior walls will be clapboarded and the roof shingled.

Drawings. The drawings upon which the contracts are to be based will consist of a plan of each floor, a roof plan and elevations of all four sides. Where the inside finish is at all elaborate, sectional drawings are made in sufficient number to show all of the rooms and halls. These general drawings, supplemented later by framing drawings and details and a carefully written set of specifications, will represent the labor, materials, and methods to be employed. The necessity of a perfect familiarity with these drawings and specifications on the part of the superintendent, is obvious and has been already dwelt upon to some length, but a few words may well be noted here in regard to the same precautions on the part of the owner and of the contractor.

The Interest of the Owner. It will be to the interest of the owner, if he will take the time and trouble, while the drawings are yet being made, to consider, with the help of the architect, the various details of construction and furnishing, and to become familiar with the drawings, that he may clearly understand just what they are intended to represent. By comparing sizes of rooms, doors, stairs and other fixtures as drawn, with houses already executed, he will be able to satisfy himself that the house when done will be according to his wish. The specifications may to good advantage be studied at home where he may receive suggestions from the various members of his family, and modifications can be readily made to meet individual preferences and tastes. Careful study of this kind will be of great value to the owner, and will often avoid later expense in altering work which, in the absence of particular instruction, will have been carried out in the usual way; and the architect will find that time spent in helping the owner, and also the contractor, to a thorough understanding of his drawings, will enable him to carry out the work with greater satisfaction to himself and to all concerned. With a complete and accurate set of drawings and specifications, a fair and equitable contract, and a thorough understanding of these instruments on the part of all the parties interested, we are well equipped to begin operations at once.

Staking Out. Upon the signing of the contract, arrangements are usually made for the architect and the contractor to meet upon the ground, to lay out the building. In our case the contractor is required by the specifications to employ a civil engineer to lay out the work and set the "batter boards". These consist of boards six or eight feet long as the case may require, securely nailed to joists which are firmly set in the ground at the corners of the cellar. (Fig. 6.) Two boards will be needed for each angle, and they are set four or five feet away from the line of the wall so as not to interfere with the excavation or laying of the cellar wall. Before proceeding to erect the batters, the position of the house has been fixed by the engineer, by setting a stake at each corner, into the head of which is driven a nail marking

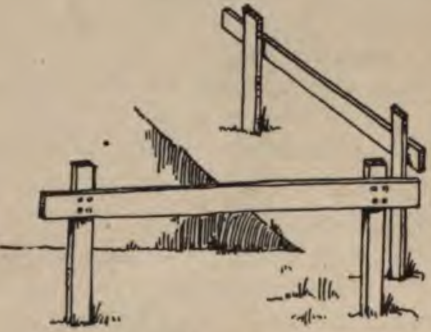


Fig. 6. Batter Boards.

the exact corner as given by the figured plans. This is often omitted but is advisable as it gives a figure which will correspond to the dimensions as figured on the plans, and any error can be more easily detected than when the lines for the walls are drawn. As soon as the corners of the house have been definitely located, the stakes for the batter boards are set and securely braced and upon these stakes the batter boards are nailed with the top of the board at some given level, usually the top of the cellar wall. Between these boards lines are stretched coinciding with the lines of the building as given by the small stakes, and when the lines are accurately drawn notches are cut in the top of the board to hold and mark the place where the string belongs. If the stakes first put down were to represent the outside line of the sill, as is often the case, we must measure out and make a second set of notches for the underpinning and back from this line we measure the thickness of the wall. (Fig. 7.) It is often the custom to drive nails into the top of the batter boards, to which the lines are tied, but this is not a good practice, as the nails are likely to be pulled out of the board before the walls are finished, and are very likely to be driven in again in the wrong place. In addition to setting the batter boards at a given level, it is always well to establish in some permanent place, as upon the top of a neighboring ledge or by a stake firmly set and well out of the way of all building operations, a datum level or "bench mark", as it is commonly called, from which at any time the levels of the work may be given.

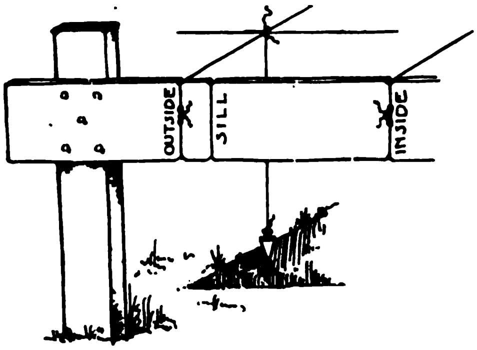


Fig. 7. Marking of Batter Board.

Space for Materials. Before leaving the grounds it will be well to instruct the builder where he can best deposit the material which will come from the excavations; and to place this to the best advantage, it will be necessary to determine in a general way, the position of the driveways or paths, and also to have a thought for future improvements and for the required drainage system. Unless this matter is taken up at this time it will be very probable that the earth from the cellar will be left so near the excavation that it will have to be driven or walked over during construction and finally moved away to its destined use, as it should have been at the start. The gravel will be needed for the driveways and paths and space for this should be found not far away from the house; and the loam will be used where it is desired to have a good growth of grass and flower beds, so we will have this piled at the front of the lot, taking care to leave ample space for the convenient handling of timber and other materials. It will be necessary to consult the builder in regard to this, as well as in regard to the depositing of earth, in order that he may not later complain that he has been hampered by lack of proper space at places convenient for the prosecution of his work.

CELLAR WORK AND FOUNDATIONS.

The next visit finds the excavation of the cellar well under way. The loam has been removed from under the house and a space eight feet wide around the outside of the house, and the cellar dug to the bottom for a great part of its extent. We proceed at once to examine the nature of the soil and find that while it is in the main a good coarse gravel, there is evidence toward the bottom of a clayey deposit which will hold water, and indeed, in the trenches directly under the wall, which are required to be eighteen inches below the bottom of the cellar, there is water standing in several places. Remembering that the specifications have foreseen that the bottom of these trenches should slope to the corner of the cellar, we direct that the slope shall be made toward a hollow in the lot and that the trench shall be extended until it meets the surface of the ground in the hollow some thirty feet or more from the house. This trench, as well as the slope of the trench under the wall, we must make with a very slight pitch lest the run of the water

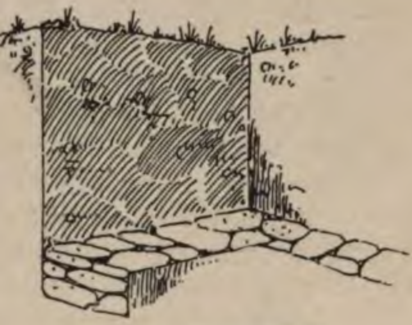


Fig. 8. Dry Wall in Trench.

should wash away the soil under the wall and cause settlements, and for greater security we must see that the lower foot of the wall which, according to the specifications, is " to be laid in dry the trenches", is well *laid* and not dumped or thrown in. (Fig. 8.) These stones should be neither large enough to choke up and prevent the flow of water through the trench nor so small as to be crowded into the ground by the weight of the walls over them, and it will be well in any case to anticipate possible settlement by ramming the first layer of stones well into the bed of the trench. In a case where the nature of the soil seems to be somewhat soft or the weight of the building is to be more than usually heavy, it may be desirable to start the walls on broad footing stones carefully bedded upon the bottom. In this case it will be necessary to make the drain entirely outside of the wall, where it may be made of tile or stones. Indeed, but for the added expense of excavation and the increased cost of large footing stones, this method would be preferable in all cases. (Fig. 9.)

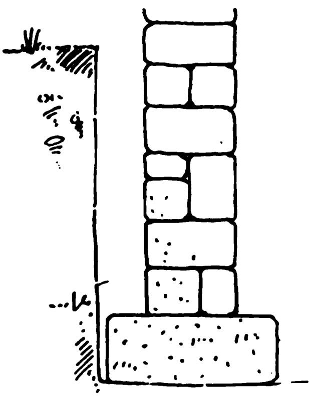


Fig 9. Footing Stone.

If on the completion of the excavating there should be found any wet spots in the cellar bottom, these must be connected by trenches filled with stone chips, with the main drain under or outside of the wall and in extreme cases the whole cellar bottom under the concrete should be filled with loose stones for about one foot of depth.

Cesspool and Drains. In connection with the excavation of cellar we should take up the matter of a cesspool, provided there is no sewer connection available. Here we will have a choice of methods. In a great many cases where all danger of contamination of wells is obviated by a city or town water service, the cheaper method of a leaching cesspool may be adopted.

Leaching Cesspool. This consists of a circular excavation eight or ten feet in diameter and deep enough to reach to good leaching or absorbent earth, lined with a dry wall of stones laid with open joints, and arched over on top with stone or brick forming a dome made water-tight, in the center of which should be set a stone, or an iron manhole. (Fig. 10.) This may be finished at the level of the ground or kept low enough so that it can be sodded over. In good coarse sand or gravel a cesspool of this kind will dispose of the sewage of a house for a great many years, but eventually the pores of the earth will become filled with the deposits and leaching will no longer take place. An effective remedy in this case may be adopted by making an outlet to which a series of pipes laid with open joints may be connected, to distribute the waste throughout a system of branches laid about twelve inches below the surface where it will be absorbed and purified by the soil and growth.

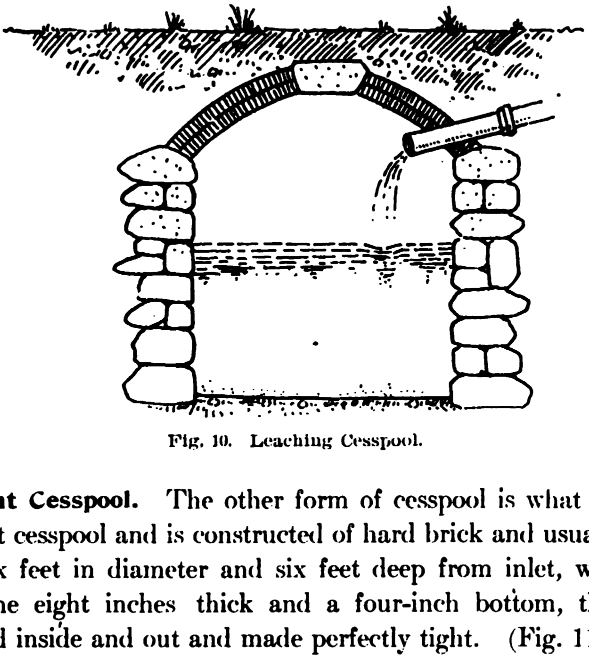


Fig. 10. Leaching Cesspool.

Tight Cesspool. The other form of cesspool is what is known as a tight cesspool and is constructed of hard brick and usually made about six feet in diameter and six feet deep from inlet, with walls and dome eight inches thick and a four-inch bottom, the whole cemented inside and out and made perfectly tight. (Fig. 11.) This cesspool will retain the whole of the deposits and must be either frequently emptied, or an outlet made of open-jointed pipe as described in connection with the leaching cesspool. This outlet should be below the level of the inlet and should have a bend turned down below the surface so as to remain in the clear water which will be found under the scum which lies on the surface. We find by the specifications that our architect has adopted a clever combination of these methods by building two cesspools, the first of which is a small tight cesspool which will retain all the solid and putrefying matter, and connecting this by an overflow pipe with a leaching cesspool built as described. The effect of this is that the tight cesspool will receive all of the solid matter which may be in the sewage, where it can be cleaned out at stated periods; and the overflow being of a wholly liquid nature will pass into the leaching cesspool in a comparatively clear state and will be absorbed entirely by the surrounding earth with no perceptible contamination.

In locating the cesspools we must see that they are placed low enough to allow the drain from house to have a good pitch. This drain will be of vitrified earthen pipe and should be laid at least three feet six inches below the surface, with an even pitch and with the bottom of the trench hollowed out where the hubs of pipes will come so that the pipes will lie flat in the trench. Great care must be taken in jointing the pipes to be sure that the cement is scraped off the inside of the pipes, where a projection would catch a portion of any solid matter which might pass through the pipes and they would soon become filled.

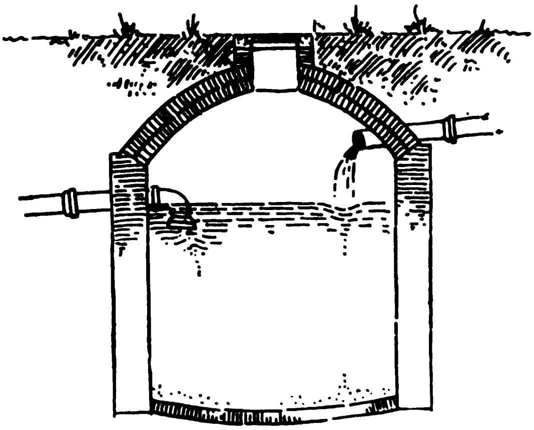
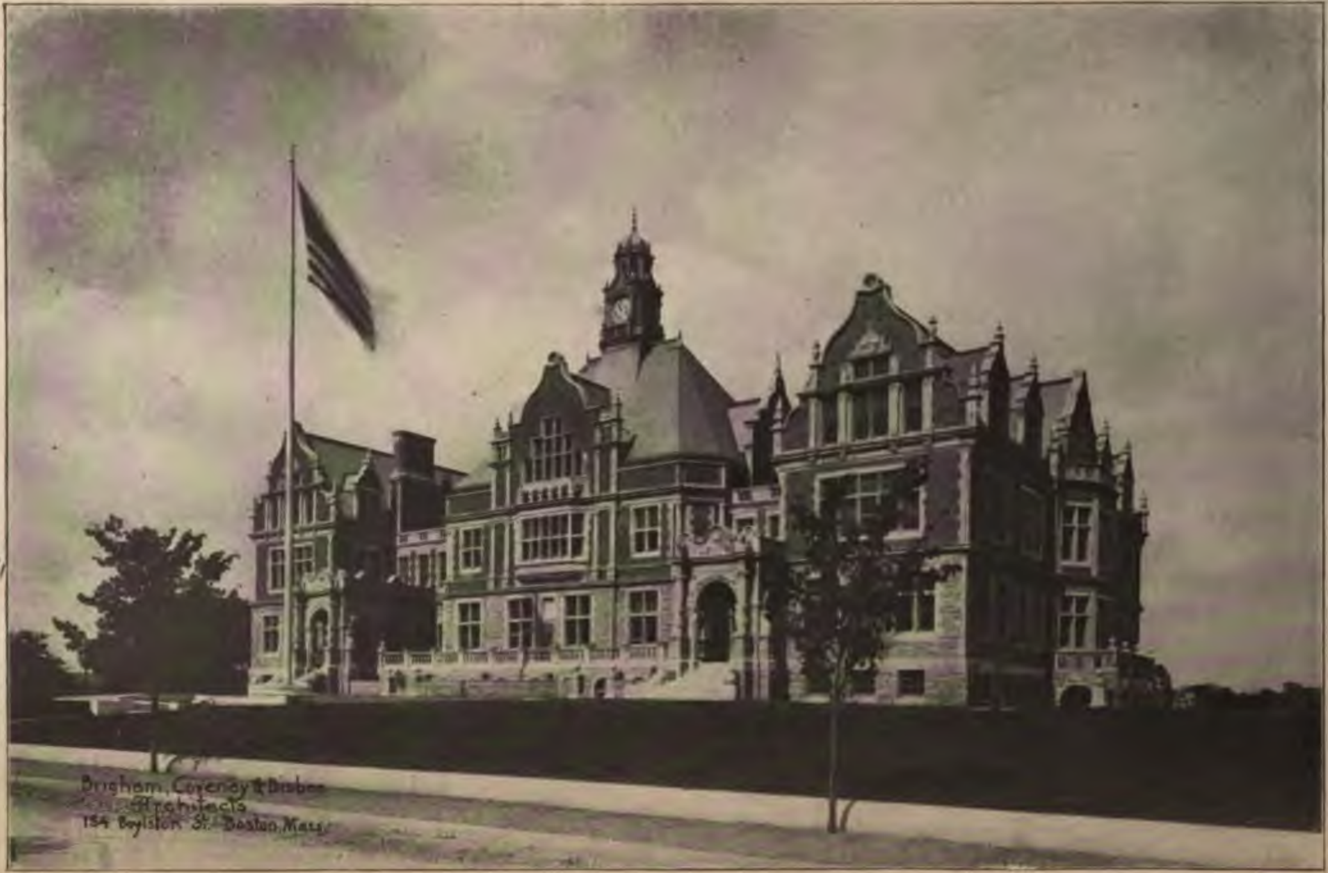


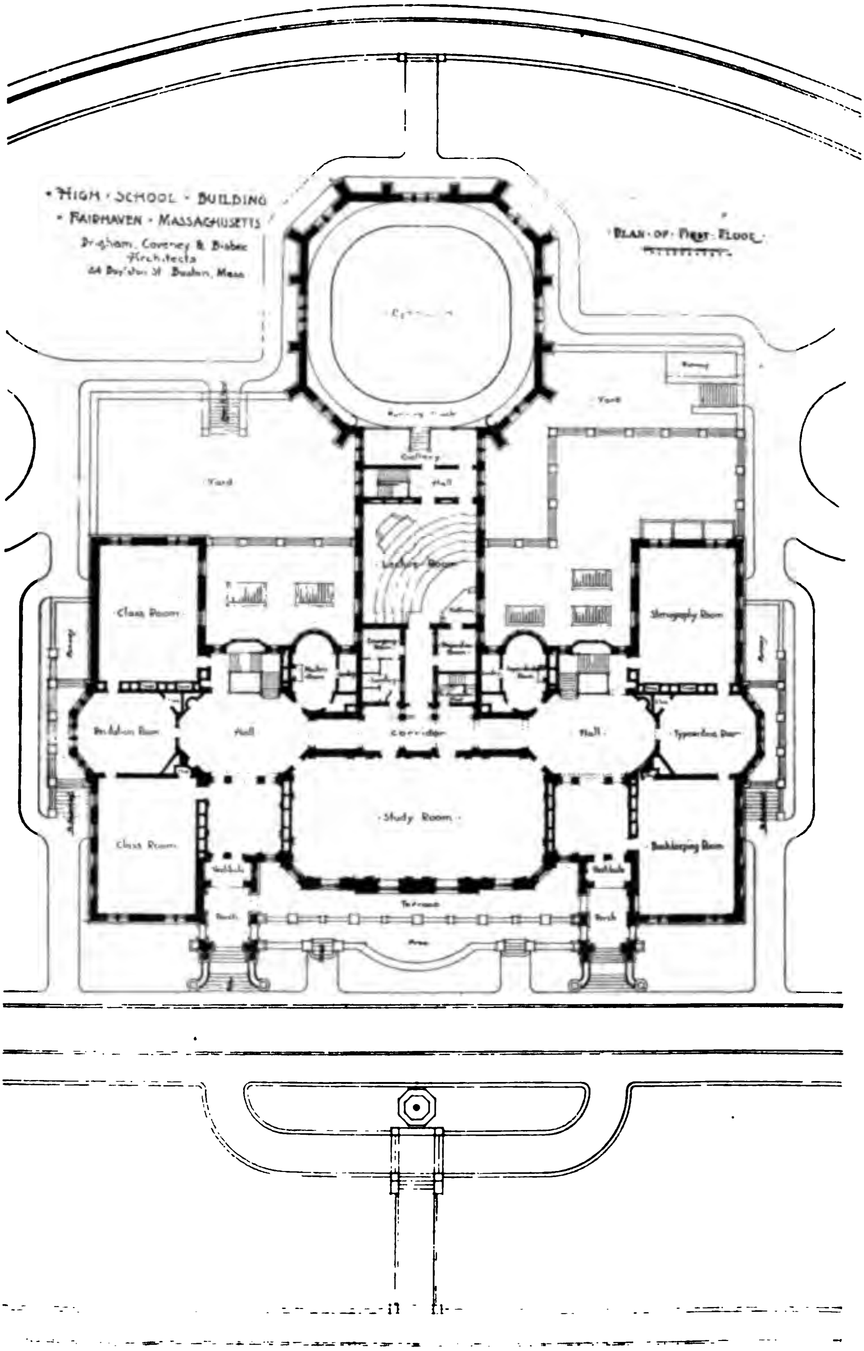
Fig. 11. Tight Cesspool.

Dry Wells. As a part of the drainage system we must provide for the distribution of the rain water from the roofs. If our house were connected with a sewer we would simply connect the conductors properly with the main drain pipe in the cellar, but as we do not want this great amount of water to run into the cesspool we will lead it



HIGH SCHOOL, FAIRHAVEN, MASS.

Brigham, Coveney & Bisbee, Architects, Boston, Mass.



PLAN OF HIGH SCHOOL BUILDING, FAIRHAVEN, MASS.

Brigham, Coveney & Bisbee, Architects, Boston, Mass.

Halls and Corridors Lined with Marble and Limestone. Wood Finish, Quartered Oak Throughout. For Exterior, See Preceding Page.

away from the house by means of earthen pipes running from the bottom of the conductors to "dry wells". These are excavations some three or four feet each way, filled with loose stones which will be piled around the end of the drain pipes and the whole covered with the grading. (Fig. 12.) The location of these wells will be determined by the position of the conductors and they must be at least eight or ten feet from the cellar wall, and farther away if there is any danger of the water finding its way back to the cellar. The waste from the laundry trays being of a comparatively clear nature we will dispose of in the same manner.

Cellar Walls. While it is necessary to consider the matter of drainage at this time, the actual work of building the cesspools and laying the drain pipes is usually taken up at a later period and the whole of our energy at this time should be directed toward the building of the cellar walls. Already the timbers for the frame are being delivered and the contractor for the carpenter work is filled with forebodings lest he have no wall to put his sill on when the first floor is framed. We direct the mason to build the cellar walls with all the speed that he can, "consistent with good workmanship", and set ourselves the task of following him up sharply to see that this is done. The greater part of the stone for the cellar walls has been carted onto the lot and we shall do well to look it over with the mason, pointing out to him that many of the boulder stones are too round and should be split before being used, while some of the more slaty stones, which appear to have been recently blasted, may have cracks in them which will allow the water to soak in. This may be detected by striking the stones with a hammer to judge of their soundness by the clearness of their ringing. The stones, upon the whole, are a good looking lot, and it will remain only to see that the walls are properly built.

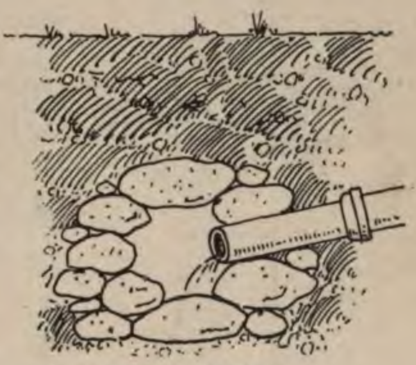


Fig. 12. Dry Well.

In the first place the walls must be built entirely free from the bank so that they are self-supporting (Fig. 13), besides giving an opportunity of cementing the wall on the outside as called for. This is a thing generally neglected, and yet is much more important than that the inside of the wall should be smooth and handsome. The ordinary careless way of building the cellar wall of a country house, is to lay the wall up to the top of the ground without mortar, of stones of varying thickness, brought to a face on the cellar side, and with the "tails" of the stone in irregular projection on the outside, some partly resting against the bank and others barely filling out to the required thickness, and the whole smoothed over on the inside by a thin smearing of mortar. (Fig. 14.) This is a method which should be avoided for many reasons. In the first place a wall of this kind is little or no protection against water, for the uneven projections on the external face serve to catch the water which runs down on the outside and to lead it into the inner face, where the thin pointing of mortar is very little protection. Then, too, any movement as of frost in the ground, tends to overthrow the wall by reason of the long stones which tail into the ground, and often bear upon the soil in such a way that any settlement or heaving of the soil will open cracks, and cause the wall to bulge inward as is often seen in country cellars. In reality it is more important that the outside face of the wall should be smooth and impervious than the inside face. Satisfied that the stones which are being delivered are suitable for our wall we shall need to give our attention mainly to the construction, to the mortar and bonding, to the solidity, and later to the pointing. The specifications say that the stones shall be laid in "half cement" mortar. This we interpret to mean *equal parts* of cement and lime, and not half as much cement as lime, as some contractors have been known to claim. In slaking the lime for mortar it is important that the water, in the proportion of one and one-half barrels to on

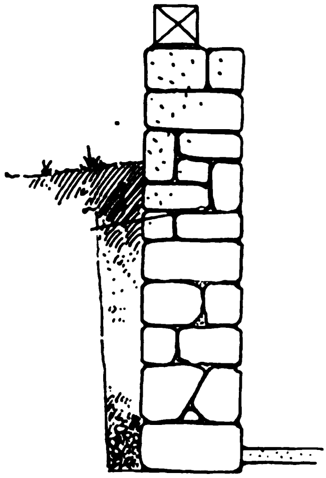


Fig. 13. Good Cellar Wall.

barrel of lime, should be added in as large quantities as is practicable, as the putting on of water by bucketfuls with time taken for stirring between, tends to chill the lime which is already beginning to heat. After slaking, the lime must stand as long as possible before mixing with sand, and the cement should not be added until required for use, as it will set in a few hours. This mortar is to be mixed in the proportion of one part of cement to one part of lime and eight parts of sand, and must be thoroughly mixed, as will be shown by the evenness of color and smoothness. To be of good quality, the lime should be free from cinders and clinkers, in hard lumps with little dust. It should slake actively and entirely, making a fine soft paste with no residue or "core". Lime should always be slaked in a pen built of boards and never on the ground or in a hollow in the sand. A pen about four feet by seven, and ten inches deep is large enough to mix a cask at a time.

Some kinds of lime, when slaked, leave a residue of stones and gravel and when this is the case instead of the mortar being mixed in the same box in which the lime slaked, the mixture is thinned with water and is run through a fine seive into another box in which the mortar is mixed. If Rockland lime is used as is specified in our case, this will not be necessary.

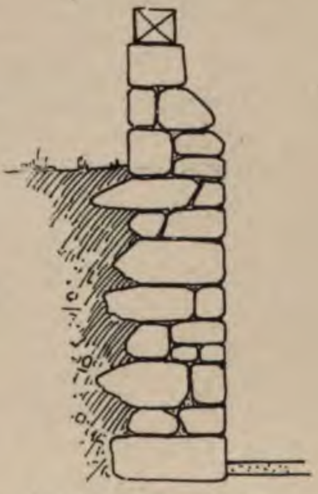


Fig. 14. Poor Cellar Wall.

Sand. The sand used, should be sharp and free from dirt, loam or other impurities. To obtain this, it is generally necessary to screen the sand. For our purpose a rather coarse sand will make the strongest mortar. The sand must be carefully inspected and in case of any doubt should be tested for purity. One test is by putting a handful into a dish of water, when any dirt or impurities will at once rise to the top as the sand sinks. Another test is to squeeze a handful of wet sand, and, upon opening the hand, if the sand retains its shape and soils the hand, it probably contains loam or clay and should be rejected. If it falls down loosely without staining it is probably clean and good. The presence of fine loam in the sand will make the mortar work more easily and it is sometimes so used by unscrupulous builders.

Cement. There are many brands of Rosendale cement, which is the kind called for, and they are so well known that for ordinary purposes it is only necessary to see that the casks bear the name of the specified brand, and that the cement is fresh and has not become crusty from absorbing moisture. The darker colors also indicate the better qualities. In case of any doubt, a simple test is to make two cakes of about a handful each mixed with a little water and allow one to set in the air, while the other is put to set in water. If the cement dries in the air with a light color and free from cracks, and sets under water with a darker color and without cracks, it is of a good quality; but if either cake cracks or becomes twisted and bubbly it shows a quality of cement which is inferior, and should be rejected. Cement must be kept in a dry place as a little moisture will cause it to set and it will soon become worthless.

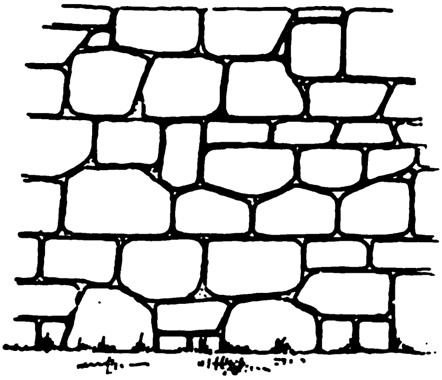


Fig. 15. Rubble Wall Levelled Off.

Cellar Wall. Upon our next visit, we find that the trenches all around the cellar have been filled and a portion of wall laid starting from the corner and running some ten feet in either direction. Our first care is to examine the lines by which the work is being laid up. We note that each line is tied to its proper notch on the batter boards and that the men are working to plumb lines hanging at intervals from the long lines (See Fig. 7), using the stones about as they come to hand, the only preparation being to square the too irregular ones, to make a face on them by the use of the stone hammer. We caution the mason to level off the wall about every two feet (Fig. 15) [illegible] to keep the horizontal joints as near to a level as possible. [illegible] call his attention to the clause in the specificatio bond stone in every ten square feet of wa the wall already built to see if this has been done. In a wall such as we require, that is, with practically two faces, there is often a tendency to build the two faces with long narrow stones and fill in between with small stones which are put in nearly dry with a little mortar on top to show well. Such a wall has an appearance of strength on the faces, but under a heavy load may fail from lacking of bonding. To detect this defect in a wall already built, and before the mortar has set, a very useful instrument is a steel rod about $\frac{3}{16}$-inch in diameter and four feet long. This will show at once, by being thrust down into the center of the wall, whether the stones are laid to overlap each other or not, and also if the stones in the center are well bedded or not, as they will rock and jar when struck with the rod if not bedded thoroughly. No stone should be set with a depth from the face of less than six inches, and all stones should be laid so that their split surface is horizontal and breaking joints in the length of the wall, as well as through and through, and all angles should be bonded alternately, using the largest stones for the corners. (Fig. 16.)

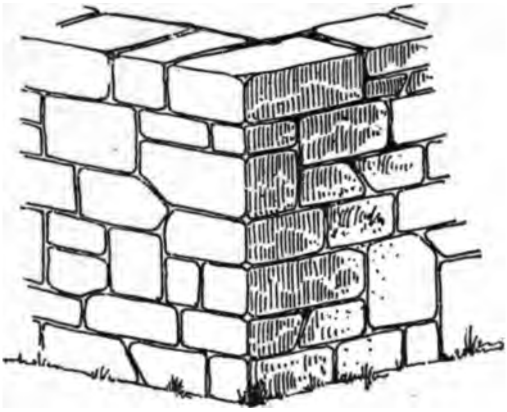


Fig. 16. Corner of Wall.

The corner which has been built, we find to be well bonded, as the first corner of any wall is apt to be when stones are plenty and near at hand (it is the last corner of a cellar wall which will need the sharpest watching), but about six feet from the corner we discover a line of vertical joints which runs irregularly but continuously, through four or five courses. (A, Fig. 17.) We call the man who is working upon this part of the wall, and point out the defect to him with instructions to take down the wall until he can bond over the second course, and we caution the foreman to watch sharply against this sort of construction. Another bad practice which some masons encourage, is that of filling the spaces between the larger stones with chips or pebbles, put in dry, and then smeared over with mortar which is more or less carefully worked into the seams. This kind of work will be easily detected by use of the steel rod, which we can feel moving the stones if poorly bedded. The right way is to settle each stone, no matter how small, into a bed of mortar either by rubbing with the fingers or by tapping with the trowel or hammer. In heavy work all large stones should be set with a derrick, as in rolling the stones up to their places on planks set up against the freshly laid wall, there is not only danger of shoving the wall out of plumb, but the bed of chips and mortar which has been prepared is sure to be torn up, and there is no certainty that the stones are properly bedded. Satisfied with the work which has been done so far, we give orders that the filling in against walls be done with coarse gravel or broken stone well puddled with water or settled by ramming.

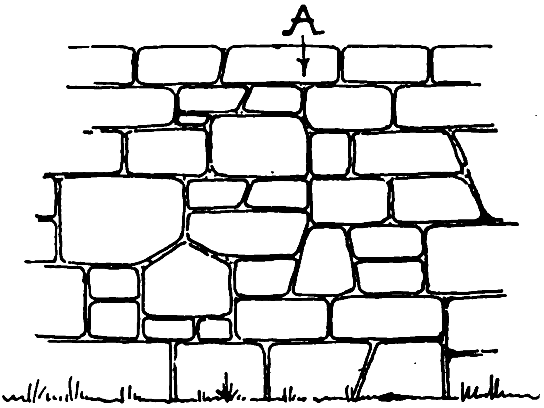


Fig. 17. Straight Joint in Wall.

Underpinning. The next visit finds the cellar wall completed up to grade and the excavation filled in to the natural level of the ground. While we have no reason to suspect that our instructions have not been followed in regard to facing the wall on both sides, we nevertheless have recourse to the steel rod. Thrusting it down alongside the wall at intervals we do not find any projecting stones, and as the digging away of the filling in several places shows that the wall is properly cemented on the outside we feel reasonably sure that the wall is built according to contract, and proceed to a consideration of the underpinning, the portion of the cellar wall above ground, which being visible, must be considered from the point of appearance as well as strength. A variety of materials may be used for underpinning. Long pieces of granite or freestone in one or more courses are often used, sometimes an eight-inch brick wall is built upon the stone of cellar and often the cellar wall is continued up to sill of the same character as below ground, except that instead of being careful to fill the face joints, they are left without mortar for about three quarters of an inch in depth from surface, to be filled later with Portland cement mortar, colored to taste, and rubbed with a tool made for the purpose to give either concave, V-shaped, or raised joint.

It is important to see that the underpinning is carried up to the sill the full thickness of the wall, leaving out spaces for girders, with the top carefully levelled off at the bottom of the sill.

FRAMING.

While the walls are being built the carpenters have been at work framing the house and are now ready to lay the sills and put on the first floor beams. The preparation of the sill consists in halving and pinning together at the corners (Fig. 18), mortising for the door and window studs, and notching out for each floor joist about two inches down into the top of the sill. The sill should be well painted on the under side as a protection against moisture from the wall, but unpainted elsewhere to allow of drying out, and should be set in a thick bed of mortar. As our sill is to set back two inches from the face of the wall, we shall have a chance to point up with mortar along the outside edge to be sure that there is no chance for cold air to get into the floors at this point.

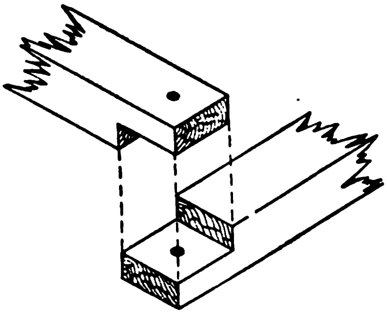


Fig. 18. Corner of Sill.

Custom allows much variation in the size of the sill, six by six being the more common size. Six by eight is called for in our case and in some cases the sill is made six by the depth of the joist. Where large sizes of timber are easily obtainable, this method is to be commended. In the first place the greater depth of timber will span all openings that are likely to occur in the cellar wall, again, the equal depth of the sill and joists leaves no space connecting the cellar with the vertical wooden wall and prevents circulation of fire or vermin without recourse to brick filling. (Fig. 19.) The sill may be bolted to the wall, but this is not usual except for light framing in exposed situations. After the sills are set, the next timbers to be put on will be the girders which support the inner ends of the floor beams. These are usually 6 × 10 inches or 8 × 10 inches for the floors of a wooden house; in our case 8 × 10 inches, and they are generally set under the bearing partitions of the house, and supported by brick piers or iron columns in the cellar. These piers or columns are generally not set until after the heavy floor beams have been put on as they would be liable to be knocked over in handling the heavy timbers, so these timbers are usually supported by shores until the piers are built.

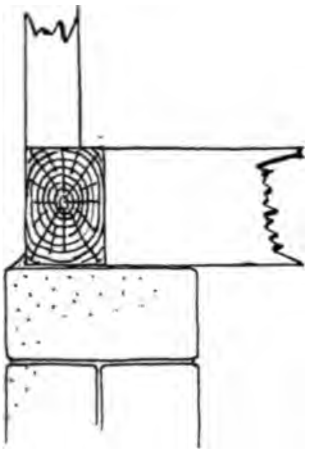
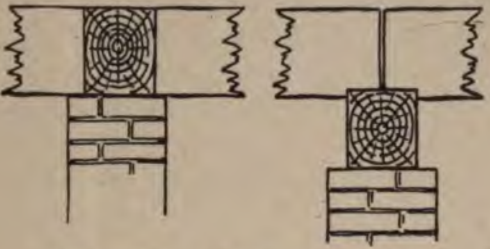


Fig. 19. Sill on Wall.

The piers of the height of an ordinary house cellar should be 12 × 12 inches, spaced, according to the size of the girders, from seven to nine feet apart.

In their vertical position, the girders may be set flush with the floor timbers, in which case each joist is framed into the girder, or they may be dropped to allow the joists to rest on top, usually notched an inch on to the girder. (Fig. 20.) The advantages of the flush framing are that the shrinkage of wood at each end of the joists is equalized, that circulation of fire by means of the interior partitions is prevented, and that the girder does not take head room out of the cellar. The advantages of the dropped girder are that the full strength of the girder is available and that it is possible to run hot air and other pipes up in the partitions without cutting the girder. If flush girders are used the position of mortises, as well as the position of the mortises in the sill should be examined by the superintendent to see that the openings framed for chimneys, stairways, etc., are correctly laid out according to the framing plans. Obvious errors will, of course, be easily detected but it will save much annoyance later if every mortise is verified before the floor is put on. When this is done the floor timbers may be set. These are usually two inches in breadth and in our case are ten inches deep. Upon these joists is invariably laid, in the East, a rough floor of $\frac{7}{8}$-inch boards either of spruce or hemlock upon which the workmen can move to carry out all subsequent operations. It has been the custom in the West to omit this under floor, but the saving is very slight and the benefits of the double floor are many. In the first place the under floor stiffens the building perceptibly, is of great convenience to the workmen, and allows the laying of the upper floor to be put off until the very last thing. This is an important consideration in these days of bare floors and has led to the adoption of the rough under floor generally. It is a good plan to lay this floor diagonally with the joists as it greatly stiffens the building and gives a more even surface upon which to lay the upper floor.



Flush Girder. Fig. 20. Dropped Girder.

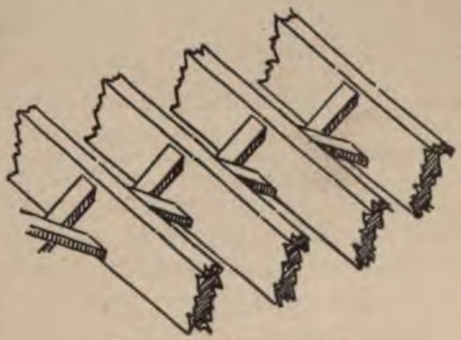


Fig. 21. Bridging of Joists.

Bridging. As soon as the rough floor is laid, and before this, if the boards are to be laid diagonally, the floor beams must be bridged, or trussed, as it is sometimes called. This consists in cutting in diagonally between the joists, strips of wood which are nailed securely top and bottom and cross each other between each timber. Fig. 21. Some carpenters reason that a piece of plank cut in vertically between the joists will serve the same purpose, but this is not so. If the floor is laid square across the joists, the usual way is to take up a board along where the bridging will come. The superintendent should look out that the bridging is well fitted and thoroughly nailed, and continuous from side to side.

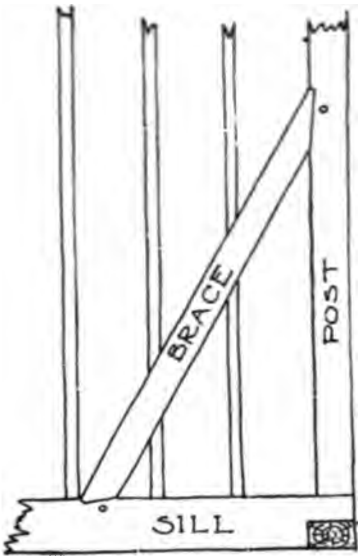


Fig. 22. Brace.

Exterior Framing. Next in order will come the raising of the exterior vertical frame, and in this relation we will have had a choice of two principles. The first and more common method is called the "full frame" or "braced frame" and consists first, of erecting at the angles of the building, posts 4 × 6 or 4 × 8. Between these uprights, at the level of the floors, are run horizontal "girts" which receive the joists of the second floor and into which are framed the door and window studs, and at the top of the wall a plate is set in a similar fashion. The angles made by these timbers with the posts, are braced by diagonal pieces framed or spiked to the horizontal timber and post. (Fig. 22.)

In the other method of exterior framing, called "balloon framing," the girts are omitted and the studs run from sill to plate. The usual way of forming the plate in this construction is to spike on the top of the studs a 2 × 4-inch piece, and on top of this another 2 × 4-inch piece, breaking joints and overlapping at the angles.

Provision for supporting the intermediate floors is made by spiking a board 1 × 6 inches into notches cut in the inside of the studs so that the top of the board will be an inch above the bottom of the floor joists. (Fig. 23.) This board is called a ledger-board and is one of the weak points of balloon framing, not in the weight carrying sense, but in case of fire, as it does not prevent the spread of the fire as would a solid girt, being more easily consumed and doubtless would let the floor fall. The floor joists should be notched over this ledger-board, which should be kept back a little from the inside face of the studs to allow space for the mortar to clinch. Another weak point is the omission of braces, which if used can only be short ones at the top and bottom, and are usually omitted in this kind of frame. A substitute for braces sometimes used, is a stout strip usually one inch by three inches cut diagonally into the outside of the studs and spiked to each. This makes a very strong brace but weakens the studding. The fact that the studs of a balloon frame run from top to bottom, requires that the windows should be as nearly as possible over each other so that one set of window studs will serve for both upper and lower windows.

The erection of the outside frame should be carefully watched to see that the door and window studs, at least, are tenoned head and foot, that all the braces are put in and properly framed, and that all the joints are snug and well pinned, the openings in the proper places, and the framing plumb and rigid. Nothing is more annoying than to find, after the outside frame is all up, that a window or door has been framed out of place, and although the builder may be obliged to rectify the mistake at his own expense, it can only be done by patching somewhere and the owner is quite likely to feel that the error might have been prevented by the more careful oversight of the architect. As soon as the frame is set up, in our case a full frame, which can be set up a story at a time (the attic joists only being carried on a ledger), the outside boarding is put on. Spruce or hemlock is used for this mainly, but it must be mill-planed to an even thickness so as to give a true surface for the outside covering of clapboards or shingles. (We find that the boarding is specified to be matched and laid diago-

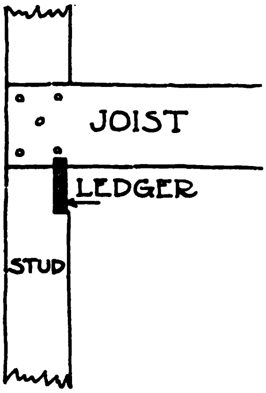


Fig. 23. Ledger Board.

nally upon the walls and square-edged for the roof. The reason for not matching the roof being that the cracks in the square-edged boarding will allow circulation of air under roof shingles and preserve them much longer than if matched boarding were used.)

When the first story studding is set and the girts are on, the inside bearing partitions must be set up to give a support for the inner ends of the second floor joists. It will not be necessary to set up all the studs of these partitions at first, but the partition caps should be run and studs set up at three or four-foot intervals and set as nearly as possible in their proper places, to avoid doing the work over again. As soon as this is done the second floor joists can be set and bridged and, with the outer walls carried up to the plate and another partition in the second story set, the attic joists may be put on and the building made ready for the roof. At this juncture we are approached by the foreman who holds in his hand a smooth board upon which he has drawn a sketch of the attic joists and ledger-board which he submits for our opinion. We examine his drawings and find that he has represented a ledger-board 2 × 3 inches notched into the studs one inch and up into the joists two inches, making the bottom of this ledger flush with the bottom of the ceiling furring. (Fig. 24.)

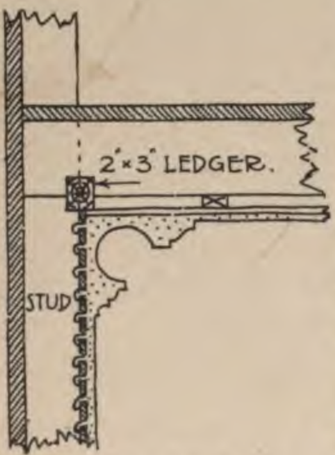


Fig. 24. 2" × 3" Ledger.

This method he puts forth as having nearly equal strength of the 1 × 6-inch which is generally used, and the merit of not presenting so broad a surface behind the lathing at the top of the second story, which destroys in a measure the key of the plaster. We consider carefully all of the features of this method and admitting that it has these features to recommend it, we can praise the ingenuity of the device. If we were to run heavy cornices at the top of our second story we would be inclined to adopt the sketch, but as we shall run only a picture moulding in the angle which will be helped rather than hurt by the presence of the wood behind the lathing at that point, we decide in favor of the usual way of putting in the 1 × 6-inch ledger, but tell the foreman to notch the studs $1\frac{1}{8}$ inches deep so that there will be a space between the laths and the ledger for a key to the plaster. (See Fig. 23.)

An important matter in carrying the outside and inside supports from bottom to top is to see that the amount of shrinkable timber is as nearly as possible the same in both outside and inside walls. For this reason the common practice of setting the partition studs upon a horizontal piece laid on the under floor should be avoided. (Fig. 25.) For instance, in our case the amount of horizontal wood in the outer wall from the rigid underpinning to the bottom of attic joists will be,—the sill at six inches, the girt at six inches and the upper part of the ledger board above its nailings at two inches,—in all fourteen inches of shrinkable wood. If the inside partitions were set on a two-inch sole resting on the under floor in each story, there would be in the inside wall, from the rigid piers in the cellar to the under side of the attic joists,—the girder at ten inches, the two tiers of floor beams with under floors at eleven inches each, and two soles and two caps at two inches each,—making in all forty inches of wood, the shrinkage of which would amount to an inch and a half or more as against a probable half-inch on the outside walls. The result, when the house has become completely dry, would be that the inner end of the floor beams would be an inch or more lower than the outer end, enough to crack the plastering,

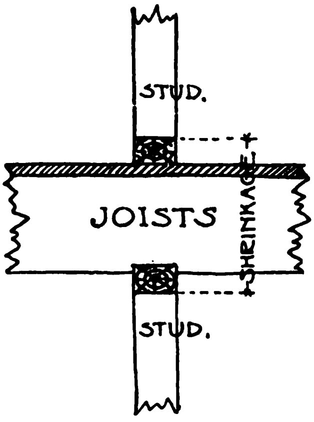


Fig. 25. Wrong Way of Setting Partition.

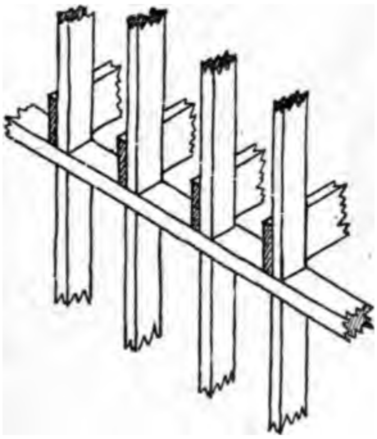


Fig. 26. Right Way of Setting Partition.

that they are made solid for lathing (Fig. 28), and that provision is made for running pipes, etc. If any of the unsupported partitions running parallel with the joists are found to have a considerable span, so that there is danger of too much sagging, the difficulty may be overcome by trussing the partition at a small cost and if by any means such a partition is used to support floors or other partitions over, this should be done in any case. The studs at the sides of all openings are to be doubled, and all openings of more than three feet are to be trussed. The head of all openings should be double, with the lower piece an inch from the upper so that if there is any sagging of the upper or weight-bearing piece it will not affect the lower one to which the finish is nailed. All the partitions should be bridged, and all sliding door pockets sheathed with end joints secured, so that there will be no possibility of a board starting off. The lining of sliding door pockets should be set upon heavy sheathing paper in such a way as to prevent air drafts from the cellar which are a source of great annoyance.

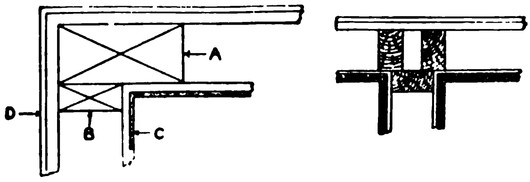


Fig. 28. Corners.

MASON WORK.

Chimneys. While these matters are being followed out by the carpenter, the mason will have started the chimneys, as the roof cannot be finished until the chimneys are topped out. The bricks which are furnished should be carefully inspected and any that are soft, or easily broken by striking together, should be ordered off the grounds at once. The specifications call for good hard bricks. If the contractor is honest he will have ordered suitable bricks, and if they are rejected the loss will be the dealer's and not his. Next in importance to the quality of the brick is the smoothness of the inside of the flues, this is best obtained in unlined flues by cleaning off, with the trowel, the mortar which squeezes out of each joint as the bricks are laid. In some localities it is customary to plaster the inside of the inches to two or three feet, twenty inches being the most usual.

For any roof of less than 30-foot span with the plate securely tied, no interior supports will be needed, and above this span, purlins should be used. The size of rafters not over 12 feet long should be 2 × 6 inches, from 12 feet to 18 feet 2 × 7 inches and 2 × 8 inches, and over that length 2 × 10 inches. On the whole it will be cheaper to reduce the length to 10 or 12 feet by means of purlins. An examination of the framing plans shows that our rafters are about fifteen feet long and two by seven inches in size, set twenty inches on centers. The roof is a hip roof, that is, a roof which draws in from all sides, which is the strongest kind of roof, so that we shall not have to provide any special supports, and shall only have to see that the proper pitch is given according to plans, that the valleys are properly put in and are extended to the ridge or to the hips, and that the openings are of the right size and in the right positions. All portions of the roof must be well spiked together, the ridges perfectly straight and level and in the center, and the rafters all set exactly to a line

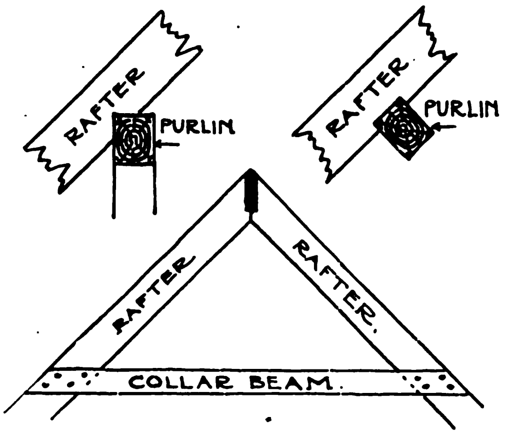
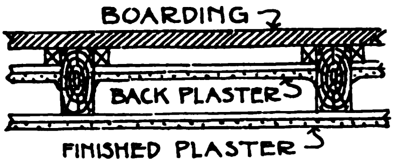


Fig. 27. Collar Beam and Purlins.

Partitions. With the covering in of the building we may turn to the completion of the inside partitions, and these must be carefully followed to see that the studs are straight and plumb. Crooked studding may be straightened by cutting with a saw on the concave side and then wedging the cut apart. All studs which bear an extra weight, as at the sides of large openings, should be examined to see that they have a sufficient support on the partition under and do not come between the studs, in which case a block should be cut in under the partition cap, and the same should be done where heavy timbers bear between studs. All corners must be examined to see are generally built entirely free and are secured to the frame by strap-iron ties, which will bend enough to adjust themselves to any settlement, either of the chimney or the frame. In the case of outside chimneys where protection from the weather becomes necessary, this natural movement between the chimney and the house must be recognized, and the chimney should be constructed with a projection of brick in line with the frame so that the boarding may run over and break the joint. (A, Fig. 29.) Where the top of a small chimney stands clear above the house for more than ten or twelve feet, it should be stayed to the roof with iron rods. Two rods should be used, spread as far apart as possible at the point of junction with the roof, to give a measure of lateral support to the chimney. Lead for counter flashing is to be furnished by the carpenter, for the mason to build into the joints of the chimney above the roof boarding, and care must be taken to see that the pieces are of good size and are carefully cemented into the brickwork at least six inches above the roof, and ready to be turned down over the flashings which the carpenter will build in with the shingles. Behind the chimney, the flashings must be built in to a height that will allow proper room for building a cricket, to turn the water to either side. The stone caps for the tops of the chimneys will have arrived, and these should be carefully measured on the ground, to be sure that they are of the right size and that the holes for the flues are large enough, and of the right shape and in the proper position. For large chimneys with thick walls, it may be necessary to make the stone cap in pieces and when this is done, the stones must be carefully tied together with galvanized iron or composition clamps. The excessive projection of bricks to form the chimney top is a thing to be avoided, one-half to three-quarters of an inch to each course being all that should ever be allowed. In determining the projection of the top, it must always be remembered that the projection at the corners will appear greater than the natural projection of the courses, and there will be more danger of finding the completed top too large than too small. Projections from the shaft of the chimney must be projected on top by a weathering of Portland cement, and where an outside chimney is reduced in size the weatherings should be of stone.

Back Plaster. With the topping out of the chimneys the mason, who in suburban work is quite likely to be the plasterer as well, should turn his attention to the back plastering if there is to be any. This is done in several ways, a common method being to nail strips to the sides of the studs and to lath upon these, plastering the whole surface between the studs with a rough coat of plaster. (Fig. 30 *a*.)

Care must be taken to bring the mortar well out on the studs and even then, when the studs shrink, there may be a continuous crack along the side of the stud from top to bottom. This, if it occurs, will defeat the whole purpose of the back-plastering and is so likely to occur that other means are often taken to obtain a better result. One of the best methods is to lath the house on the studding and plaster a rough coat and then fur off with $\frac{7}{8}$-inch strips and lath and plaster again for the finished work. (Fig. 30 *b*.)



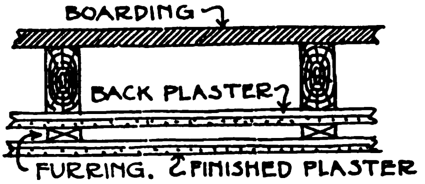


Fig. 30*a*. Back Plastering Fig. 30*b*.

Fire Stops. In connection with the back plastering, may be done the fire-stopping of plaster or bricks, the principal points being to build up on the underpinning behind the sill to the underside of

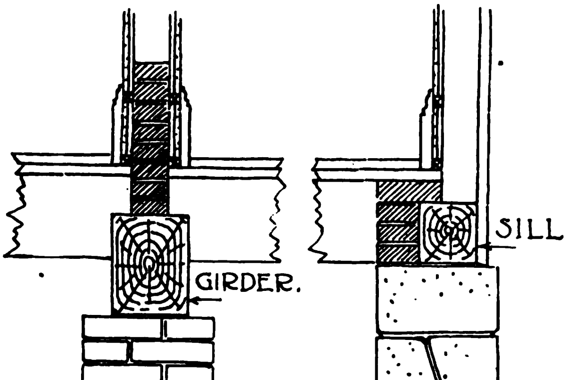


Fig. 31. Brick Filling.

floor with brick, not only to prevent the spread of fire, but to prevent rats from going from the cellar up into the walls and so all over the house. On the top of girders the same thing should be done, and if they support partitions, the brick work should be carried up between the studs for a distance of three courses or more above the floor. (Fig. 31.) By repeating this upon each partition cap and upon the girts of the outside frame, the whole house will be cut up into compartments and the circulation of fire and vermin materially checked. In the case of a balloon frame where no girt occurs, it is customary to run the floor boards out between the studs and to build up on these with the bricks. A further precaution and a valuable one is to lay a few courses of bricks upon the bridging of partitions; this will cause any fire which may be started below, to break out into the room, where it will be discovered before it is likely to reach the story above. The spaces between stair stringers and around chimneys should also be protected by fire stops of brick or plaster.

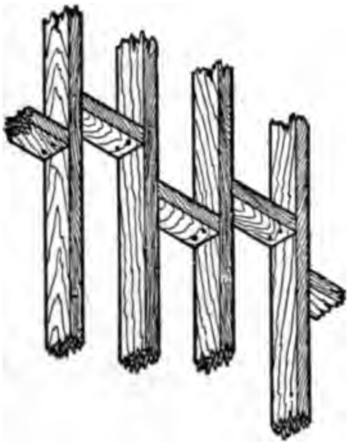


Fig. 32. Horizontal Bridging of Partition.

Furring and Finish. As soon as the roof is on and boarded, the gutters will be put on and the roof shingling begun. The position of the gutters must be carefully noted to be sure that the edge is on a line with the roof boarding, otherwise the gable finish will not work out right. The position of the conductors should be determined, and the gutters set with a slight fall toward them, and holes for the lead goose-necks should be bored, in order that no water shall stand in the gutters. With the completion of the gutters the shin-

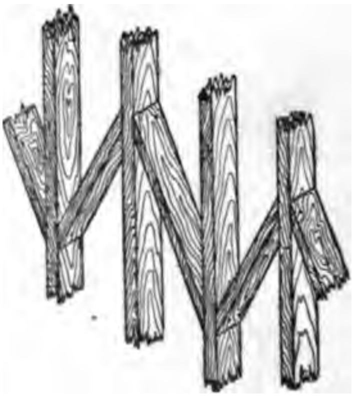


Fig. 33. Diagonal Bridging of Partition.

gling or slating of the roof can be commenced, and before the roof is completed the furring of the inside will be taken up.

Furring. Beyond the setting of minor partitions which were not needed for the support of floor beams, the principal work of interior framing will be the furring of chimney breasts, and the forming of beams and arches. The position and size of all doors must be carefully verified, especial care being taken to allow the proper width for door casings where doors come close to the corner of any room. When the studs of all interior partitions are set up they must be bridged. This is often done by cutting in horizontal pieces between the studs (Fig. 32); but a better way is to cut in the pieces diagonally (Fig. 33). The chimneys must be enclosed by vertical studs, usually 2 × 3-inch or 2 × 4-inch, set flatwise and at least an inch away from the brick (Fig. 34), with an ample opening left for fireplaces, well trussed. All door openings must also have a truss over them, and any partitions which have no adequate support beneath them should be trussed if the arrangement of doors will by any means allow it.

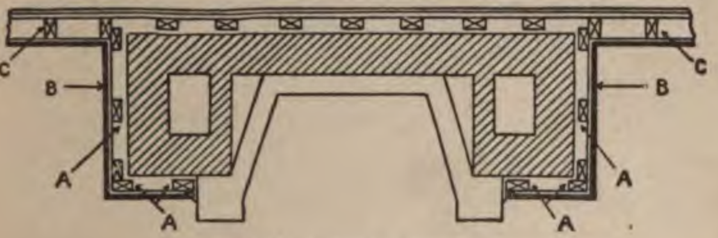


Fig. 34. Chimney Furring.

The ceilings will be cross-furred with ⅞ × 3-inch strips, commonly called "strapping". These strips should be carefully levelled and straightened, as upon their evenness depends the smoothness of the ceiling, and above all it is necessary that the strips are well nailed to every joist. Grounds are next set and angle beads for lathing, but before any laths can be laid there are a number of things to be considered.

Furnace Pipes. In the first place, all hot air pipes which are not intended to be exposed must be put in position. If a hot air system has been selected the position of the pipes and registers will have been marked on the plans, but it frequently happens that in the execution, changes will suggest themselves or will be required by unforeseen circumstances, so that the superintendent should make a personal study of the piping at the building. Where it is possible to arrange it, the pipes should be run through closets, exposed to view, but this cannot always be done, and it often happens that the chimney breasts and sometimes the partitions must contain hot air pipes. The best and safest way to do this is to make the pipes double with at least a half-inch air space between the outer and inner pipes. This is expensive and is not generally done, but instead the woodwork which comes close to the pipe is lined with bright tin, and heavy wire lathing is used in front of the pipes instead of wood laths. Where the pipes are carried through the partition or woodwork a sleeve of bright tin half an inch larger than the pipes all around should be provided as a safeguard against over-heating of the pipes.

Plumbing and Gas Pipes. Although it is customary now to run the plumbing pipes outside of the plaster, there will be some ventilation pipes that will need to be provided for at this time. All of the enclosed gas piping must be done before lathing. From the fact that the gas piping must be carried in almost every case to the center of the ceilings, there is need of careful watching lest the cutting by careless workmen shall weaken the joists. The specifications distinctly state that no floor beams shall be cut into, more than two feet away from their bearing, but as this means that all outlets in the center of ceilings must be reached by branch pipes between the joists, entailing more piping and labor for the gas fitter, there is a great temptation to disregard instructions, and to cut the joists for a straight run from center to center of rooms. Only constant watching will prevent this being done. Care must be taken that the pipes are run with a continuous drop toward the meter, to allow the liquid, which will always be condensed from the gas, to run off; and for the same reason, wall outlets must be piped up from below and ceiling drops should be taken out of the *side* or *top* of the pipes. The position of all outlets must be verified, especially those which are centered in the rooms, and they must be set at right angles to walls and ceilings. This can be verified by screwing on to each outlet, as soon as set, a piece of pipe a foot or more in length and testing with a steel square. No "gas fitters" or other cement should be allowed, but all pipes should be put together with red lead. The outlets to receive fixtures should be strongly secured to prevent springing or movement in the plastered work.

Testing. When the piping is all in place the outlets are to be capped and the whole system tested for leaks, and accepted by the local gas company. This test consists, briefly, in attaching to one of the outlets a mercury gauge, and then filling the pipes with air under pressure till the mercury in the gauge stands to the required height to insure tightness, which is usually six to twelve inches. The apparatus is then left to stand for ten or fifteen minutes, and if the mercury still holds the same level it is safe to say that the pipes are tight. Leaks may usually be detected by the sound of the escaping air, but often ether is put into a cup attached to the pump and forced in with the air, so that leaks, especially in concealed parts of the piping, may be detected by the odor of the ether. Suspicion of a leak in pipe or fittings may be verified by brushing strong soap-water over the place, when a bubble will be blown by the escaping air. Small pin holes in the pipe or couplings may be tamped, and if thus rendered tight will remain so, but pipes showing a split or large hole must be replaced.

Electric Wiring. All country houses, unless in very remote situations where there are no chances of an electric current ever being obtained, should be wired for electric lights. The usual method is the knob and tube system, where the wires, of copper heavily insulated, are run between beams and studs on porcelain knobs, and in short porcelain tubes where passing through timbers. (Fig. 35.) Although the insurance exchanges, employ inspectors and require that every job of wiring shall be reported to them and inspected by their men, it will be well for the superintendent to carefully watch this construction to see that all wires are thoroughly insulated and at least 3 inches

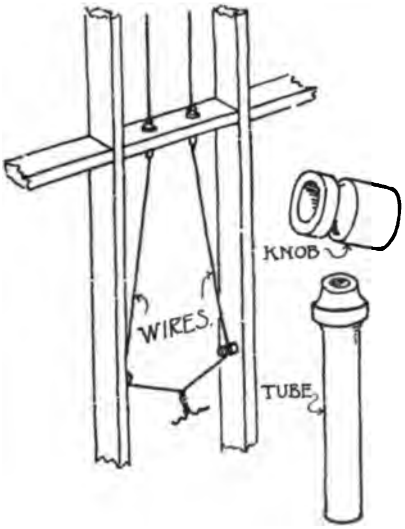


Fig. 35. Electric Wiring.

apart to avoid any chance of contact, that they are not allowed to sag, and that the joints are properly protected by a free use of insulating tape. Upon brick or stone walls, and in all places where there is danger of injury, wires should be run in conduits or pipes. In this case the angles and bends of the conduits must be made in easy curves so that the wires may be easily "drawn in". All wiring should be tested when installed and again at completion of the building, to insure against any mechanical injury. For electric bells, it is usual to run an insulated wire secured to the studs by staples, and care must be taken to see that bells as well as light outlets are placed in convenient places. If the bells are to be operated mechanically the wires should be run in zinc tubes, but as such wires stretch and break in time, the electric wires are generally preferred.

OUTSIDE FINISH.

Before the building is ready for the plasterer, the outside and the roof must be made tight. We have seen that the gutters are set and primed or oiled to protect them against water; and above the gutter, and rebated or tongued into the back, is set the "shingle facia", a vertical board varying in width according to size of gutter and pitch of roof. This facia is usually bevelled off on top to receive the butts of the first course of shingles. (Fig. 36.)

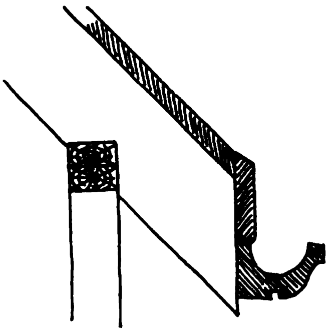


Fig. 36. Gutter.

Shingles. The shingling of the roof begins upon the facia with a double course projecting a little, and from the butts of these shingles are measured off the courses of the roof. Unless the roof is very steep the courses should not exceed four-and-a-half inches for the ordinary length of 16 inches, as cedar and redwood shingles are usually sawn. Cypress shingles are found 18 or 20 inches long and are the most durable of all shingles, but redwood and cedar, especially cedar, are more commonly used. Regarding durability, cypress shingles have been known to have lasted more than a hundred years, redwood shingles from 25 to 50 years, and cedar shingles from 12 to 20 years.

Paper. The question as to whether paper shall be put under shingles or not, is open to argument. If the shingles are laid without being dipped in paint or with the butts dipped only, the presence of paper will cause sweating, and, preventing any circulation of air under the shingles, will cause them to decay much sooner than if no paper is used; but on the other hand if the attic is plastered there is danger of damage from leaks and from fine snow sifting under the shingles. In the present case the attic is to be unfinished and we will use no paper on the roofs. The ridge of a shingled roof is usually finished by means of saddle boards nailed over the tops (Fig. 37), but sometimes an ornamental cresting is used. Hips are best finished by what is called "saddle board" shingling, in which a course of shingles is put over the roof shingles laid at right angles with the hip. There is little danger of roofs leaking at the ridges and hips, but the hip shingles unless well nailed are liable to be blown off. The plane surface of the roof, if reasonable care is taken, should afford no liability of leaking, but dormers, chimneys and valleys are sources of great danger. The flashing against chimneys and the vertical sides of dormers is done by means of pieces of tin or zinc about 7 inches square bent in the middle, so that one half will lay in the course of shingles and one half turn up against the vertical wall, to be covered by the shingles of the wall or by the counter-flashing of the chimney. In the Eastern States zinc is generally used for flashings, but in the West tin is the common material. In the forming of valleys, two methods are followed, that of an "open" or a "close" valley. In the former case the shingles are kept apart six or eight inches and the valley is made of zinc or tin, often in long strips locked and soldered at the joints and running under the shingles from four to six inches. The defect in this method of a continuous piece of metal is that there is no chance for the metal to expand and contract in its length, without danger of straining the joints and even of starting the shingles or slates which are laid over it. For this reason the use of separate pieces, the length of the shingles or slates and shingled in with each

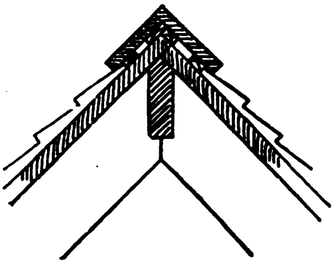


Fig. 37. Ridge Finish.

course, is to be preferred. These are bent, and lapped in the same way as the shingles without soldering and are free to expand and contract without damage.

In the case of the "close" valley the shingles are laid close together at the angle and narrower pieces of zinc or tin are shingled into each course. The flashing of roofs is a matter which needs a great deal of attention on the part of the superintendent, especially to see that wide enough metal is used. Counter-flashings are often omitted unless specially mentioned and should always be built into brickwork if possible. If not built in, it must be carefully wedged into joints which have been raked out, and pointed with cement. Every part of the flashing of a roof should be examined by the superintendent and it must never be left to the care of the builder or the workmen.

Slating. With slating or tiling greater care is necessary than with shingles. Neither slates nor tiles will lay as closely to the roof, or to each other, as shingles, and for this reason, the boarding should always be matched, and tarred paper always used, as circulation of air is no object with slates. The lap of slates should vary with their length, always allowing at least three inches head-cover, that is, each slate must lap three inches below the head of the second slate below it. Tiles are constructed with a variety of joints and laps, each designed for the needs of the different forms of the tiles. Both slates and tiles should be put on with galvanized nails, which must not be driven too hard for fear of cracking and yet hard enough to prevent loosening or rattling, and if the cost is not too great, copper should be used for all gutters and flashings. It is a good practice to lay the first three or four courses of a slate roof above the gutter in elastic cement, and also all hips and ridges.

Window Frames, Following the completion of the roof will come the preparation of the side walls to receive their finish, and the first thing to be done is to set the window frames. In wooden houses the stud will usually make one side of the weight box, and the frame will consist only of the "pulley stile" and casing. Sometimes the boarding is kept back from the edge of the studding and the casing is set upon the studding with a piece of finish or a "back-band", put over the joint with tarred paper, or better still, strips of zinc, to keep out the water. (Fig. 38.) In case the frame is set against the usual four-inch studding the outer casing will form one side of the groove in which the sash slides, but in the other case there will be room to put a strip five-eighths or three-quarters of an inch wide inside of the casing, moving the sashes in and leaving a space for mosquito guards. (Fig. 39.) The top of the frame must be flashed with lead and the bottom of the sill grooved, to receive the top of the shingles or clap-boarding, which will be begun as soon as the frames are set. Pockets of canvas, in which the window sill is set, are advisable in exposed situations.

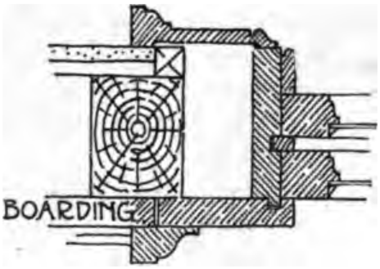


Fig. 38. Window Frame Flush with Boarding.

Porch and Piazza. Before the clapboarding or shingles of the walls can be completed, the porch and piazza finish must be put up. The floors should be framed with the joists running parallel with the house walls so that the boards will run in and out, and they must also pitch away from the house at about the rate of two inches in twelve feet. The tops of the piazza joists should be set about six inches below the main house and it is a good plan to bevel off the tops, leaving only a narrow edge for nailing, so that the water, which will run between the joints if the floor is open, will find little surface to remain upon. (Fig. 40.) Sometimes the joists and girders are covered with tarred paper. The roof of the piazza, which is covered with tin, will need especial attention to see that it is given a proper pitch and that the tin is turned up against the boarding of the house wall at least six inches to be clapboarded over. The quality of the tin should be examined and care taken to have it painted on the under side before being laid, and that the joints are well locked and soldered. Blocks must be set on the tin roof and flashed and soldered, to which

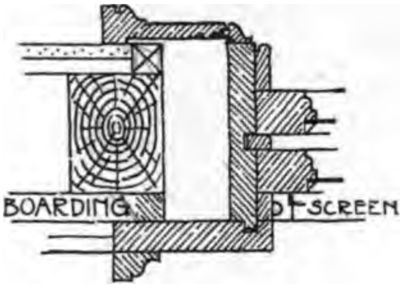


Fig. 39. Window Frame Outside of Boarding.

the balcony posts are to be secured; and where the finish of porch or piazza ends against the house, great care must be taken that the connection is thoroughly flashed with lead.

Clapboarding and Siding. Clapboarding is done in sections, from staging successively lowered as the work progresses. Each section is built upward from the staging, its top board being slipped under the lowest board of the preceding section, which has been left unnailed along the bottom for that purpose. The term "clapboard," in New England, corresponds to "siding," as used elsewhere. Clapboards are all quarter-sawed, being cut from the log by a circular saw which cuts always toward the center; they are cut four feet long, six inches wide and half an inch thick at the butt. Siding is of similar section but a little thicker, and is commonly sawed the same way as boards, in lengths of twelve to sixteen feet. Either clapboards or siding make a good wall covering, and the best should always be quarter-sawed and laid over a good quality of sheating paper, which is generally put on in horizontal layers, each layer being lapped about two inches and breaking joints with the paper and flashings already put behind the finished work.

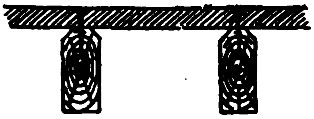


Fig. 40. Piazza Joists.

There are many good brands of paper on the market, with very little to choose between, the principal qualities required being toughness and soundness. A kind of siding called "novelty siding" is often used for cheap summer houses. This is nailed directly to the studding without any rough boarding, but the omission of the rough boarding—it should be noted—is always done at a great loss in strength and warmth.

Wall Shingles. If the walls were to be shingled, the same care would have to be taken as in shingling the roof, except that the shingles on the walls may be exposed five or six inches and they may be of a quality called "clears," in which the exposed lower third is free from imperfections. Shingling undoubtedly makes a warmer coating than clapboards or siding, as there are always three thicknesses of shingles to one of clapboards; but the choice between shingles and clapboards is generally determined by the character of the building and the effect desired.

wooden laths, will tend to prevent cracks which will occur if wooden laths only are used. For exterior plastering galvanized oı painted lathing should be used, furred at least seven-eighths of an inch from the boarding.

Plastering. With the completion of the lathing the house will be ready for the plasterer. Already the mortar will have been mixed, and, piled in large stacks, should have been standing for a week or more. The sand and lime having passed the same scrutiny and tests which we employed when making the mortar for the mason-work, the only thing necessary will be to see that the mortar is well mixed and tempered and that hair of the proper amount and quality is added at the proper time.

Mixing. For the best result the lime should be thoroughly slaked at least twenty-four hours before adding the hair, which must be thoroughly beaten up and mixed with the lime paste with a hoe, and the necessary amount of sand added. This mixture should then be stacked outside of the building as long as possible before being used, in our case at least ten days. When ready for applying small quantities of this mixture are wet up with water to the proper consistency, tempering, this is called. Unless particular care is taken the sand and hair will be added as soon as the lime is slaked as it is much more convenient to do; but this should not be allowed as the lime does not always get wholly slaked and the steam and heat of the slaking lime will burn the hair and destroy its strength.

Another practice which should be avoided, is that of mixing the mortar in the basement of the building as the steam and moisture will penetrate to all parts of the building at a time when the immediate application of the plastering gives no opportunity for drying off. In regard to the proportions, about one and one-half bushels of hair and three barrels of sand to a cask of lime is a good ratio, but the amount of sand will in ordinary cases be determined by the judgment of the mixer, who should be a competent and experienced man.

Applying the Mortar. When the mortar is ready for putting on the laths, we must see that the first or scratch coat is well trowelled to push it through the spaces between the laths so as to form a good key. In ordinary two-coat work this first coat is put on thick enough to come within an eighth of an inch or less of the face of the grounds and beads, as the finish or skim coat is merely a thin veneer of lime putty and fine white sand, trowelled and brushed to a hard surface. In three-coat work, the first coat is put on about one-quarter of an inch thick and when somewhat hard it is scratched with diagonal lines nearly through to the laths. As soon as this coat is dry, the second coat is applied and brought to a plane with all angles and corners true and plumb. On large surfaces or important work this is best done by running "screeds", which are strips of mortar six to eight inches wide and three or four feet apart, carefully laid and levelled and plumbed with corners and angles made true and brought to the line of the second coat, which is filled in between these upon the scratch coat and brought to a line by running straight edges from screed to screed. Upon this second coat is applied the third or finishing coat, usually either the skim coat as upon two-coat work, or a "white-coat" which is made by mixing plaster of paris and marble dust with the lime putty. If a rougher finish is desired, as for frescoing, a coarse sand in greater quantities may be mixed with the lime putty and floated with a pine or cork-faced float. By consulting the specifications we find that this finish is called for in two-coat work to be left "medium rough."

Screens. Before the plastering is begun the windows must be closed in with screens made of cotton cloth tacked upon wooden frames, made to fit the window frames. These are not only to protect the plastering from freezing, by which ordinary lime mortar is completely ruined, but also to prevent unequal drying of the finished walls which will occur near the windows in good breezy weather.

Exterior Plastering. The plastering of exterior walls is done to a large extent in Canada and the British possessions and is used to increasing extent in the United States. This is best done over matched boarding by furring off with seven-eighths inch strips and using wire or other metal lathing which later events have shown is better if galvanized or painted. The plastering should be three-coat work, with one-third of Portland cement for all three coats, the last having the coarse sand or gravel if a rough finish is desired. If metal lathing is not easily procured a good result is obtained by lathing upon the boarding diagonally in one-and-one-half inch spaces and repeating the lathing diagonally in the opposite direction, all well nailed and secure. Upon this we may plaster as upon the metal lathing.

Concreting. When the last of the plastering has been completed the concreting of the cellar should be begun so that it may be drying out with the plastering. For this the best cement must be used, mixed in the proportion of one shovelful of cement to three of sand well mixed, and to this added five shovelfuls of screened pebbles or broken stone, this should be at once spread upon the floor and puddled and trowelled to a perfectly level surface, the whole topped, when hard enough, with one-half inch of clear Portland cement.

Fireplaces. While the plastering and concreting are drying out the finished fireplaces are usually built. These are to be of bricks and should be built with a splay of from six to eight inches to the sides. (See Fig. 34.) The back lining is built up plumb for about six courses and then inclined toward the front until an opening of only about two inches is left. (Fig. 42.) If a flat arch or level bricks are used for the opening there must be provided a wrought iron bar, or better, two bars which must be let up into the under side of the bricks so as not to be seen. Care must be taken to see that fireplaces are set in the exact center of chimney breasts and rooms, and also that the face of the bricks are set in the required position, usually flush with the plaster line, although this may be varied to allow for differences in the form of mantel desired.

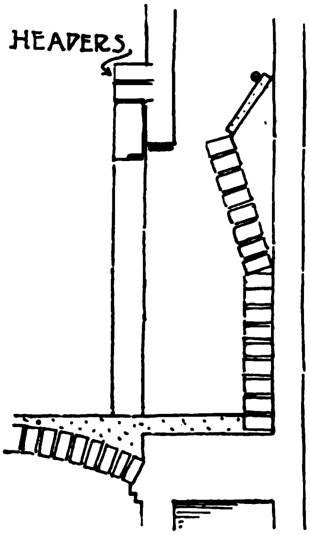


Fig. 42. Section of Fireplace.

PLUMBING.

As soon as the plasterers have removed their stagings from the house, the plumber can at once complete his piping work. In some cases it will have been necessary to run the main soil pipes concealed behind the plaster, but it is much better if they can be run in plain sight. Extra heavy pipe is called for, to be plain and painted on the outside with red lead. These pipes should have been tested for sand holes before delivery and being plain any imperfections in the casting may be readily seen, as would not be the case if they were asphalted as usually seen. The joints of the soil pipe will need especial watching to see that they are not slighted in any way. All the joints must be made of oakum, driven in tight, and finished with melted lead which will be poured around each joint and then caulked all around after the pipes are in position. (Fig. 43.) It is never well to complete the joints before securing the pipes in place as the jar of this handling may loosen the lead. The pouring in of melted lead will not secure a tight joint as the lead shrinks away upon cooling and it is necessary to force it again into contact with the pipe. This is the object of caulking, and if well done the lead in the joint will show marks of the iron all around.

Lead Pipes. Lead pipes will be most easily examined on delivery, when the ends of the coil will be stamped with some figures or letters to denote the weight per foot. After the pipe has been cut it will be next to impossible to tell if it is the right weight by appearance. All lead pipe which is not new should be rejected, as well as any showing unequal thickness. The running of lead pipes should be carefully watched and boards should always be put up, against or upon which the pipes may be securely fastened. Lead pipes which are run vertically should be fastened by hard metal "tacks", which are soldered to the pipe at intervals of about three feet. Unless this rigid fastening is done, the pipes will "crawl" and droop downward by alternate contraction and expansion. Horizontal pipes may be secured by bands but should have a continuous strip of wood to support the entire length, or they will in time sag down and form a hollow place, from which the water cannot be drawn when pipes must be emptied. The pipe should be made to rest upon the straight support and never be allowed to take an upward bend in its level course, as a bend of this kind will soon become filled with air and will eventually stop the flow of the water unless punctured at the highest point.

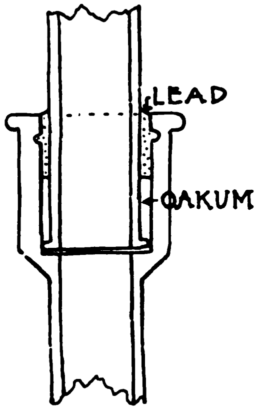


Fig. 43. Joint of Soil Pipe.

All the joints in lead pipes should be wiped joints as specified and no cup joints, which are more easily made, but not so strong, should be accepted. The joining of lead and iron pipes must be made by wiping to the end of the lead pipe a strong brass "ferrule" which can be caulked into the iron pipe. This will need to be looked out for as it is a great temptation to many plumbers to putty the lead pipe into the socket of the iron pipe.

Brass Pipes. For the hot water system brass pipes are to be used as they are not affected by the alternate warmth and chill of the water, which would cause lead pipes to sag between the supports. Indeed, if the additional expense is not too great, it will be worth while to make all the supply pipes of brass, which can be obtained either plain or coated inside with tin. If brass piping is used it must be put up so that the angles and bends are free to move a little, or the expansion and contraction will strain the fittings and produce leaks. The effect which the water will have upon the pipes is a matter which should be considered, but can only be determined by local examination, and recommendations as to the use of piping must be made with reference to the analysis of the local water supply. If brass piping is used it should be semi-annealed and specified as "iron size", that is, the thickness must correspond to that of iron pipe of similar size, as distinguished from so-called "plumbers tubing", the use of which is not to be recommended.

Iron Piping. If the cost of brass piping proves to be excessive, a good quality of iron pipe may be substituted where there is danger of corrosion of lead or of its bursting by great pressure. Iron pipe may be obtained with a lining of block tin, which forms a pure and very satisfactory channel, or a galvanized or zinc coating may be used which will be less expensive. The same methods of piping will be necessary in running iron pipe that we have mentioned in piping with brass, and besides, we must take precaution against condensation which will take place upon iron pipes in warm weather, from the fact that iron conducts heat so rapidly. This condensation will be so great that it may on occasion trickle down and cause damage to paper or decorations. Where there is this danger, the pipes should be run in tubes of zinc which will conduct the water to a safe outlet. This precaution should be taken, even in the case of lead or brass piping, when costly decorations or papers are liable to injury from bursting or leaking pipes.

The fastening and joining of all pipes should be carefully watched to see that they are run in straight lines, with free angles, and that hot water pipes are separated by a little space from cold water pipes so that there will be no transmission of heat from one to the other. All pipes must be run so that they will pitch toward some faucet or waste cock, which must be provided in convenient places and in sufficient numbers to shut off and drain both hot and cold water pipes in any given part of the house, as well as the whole system. In New England it is customary to supply the bath boiler from a separate tank in the attic, this tank being supplied from the regular house service with a ball cock to regulate the supply. The supply from the boiler to the various fixtures is made to return again to the boiler for circulation, which allows hot water to be drawn at once at each fixture. From the highest point of the circulation a small "expansion pipe" is run to the tank and turned over the edge to dicsharge just above the water line, in order to allow the steam and froth from the boiling of the water to escape into the tank. This tank should be supplied with an overflow to some convenient fixture. Outside of New England the tank is generally omitted and the boiler supplied from the house system, but this requires a strong boiler, usually of galvanized iron and is not so satisfactory as the expansion system.

Waste Pipes and Traps. The waste pipe or outlet of every plumbing fixture must have, as near as possible to the fixture, a trap, to prevent foul odors and sewer gas from issuing. The simplest form of trap, and in its improved forms one of the best, is the S-trap. (Fig. 44.) This consists of a piece of pipe bent into the form of the letter S, with a screw in or near the bottom to allow of cleaning out. The theory of this trap is that some of the water which passes through will remain in the trap, as shown in the cut. In actual use, however, if enough in volume runs through to completely fill the outlet, the falling water will create a vacuum at A, which will cause the outside air to force out the water in the trap until it falls below the bend B, thus destroying the seal. If, however, an inlet is provided at the highest point of the trap A, the vacuum in the outlet pipe will be filled from this source without disturbing the water in the trap. This inlet pipe must, of course, be carried to some main air pipe; and so it is customary to run beside the main soil pipe a line of "vent" pipes to which the different trap vents are attached, the main vent usually starting from the base of the soil pipe and entering the same again above the highest fixture. A greater danger exists where two or more fixtures are connected with the same soil pipe. In this case the seal of the lower fixture will be broken by reason of the column of water discharged from the upper fixture, creating a partial vacuum in the soil pipe and the outer air rushing in to fill the void by the easiest way, will force the water out of the trap below. (Fig. 45.) This is a real danger, and should be guarded against by venting the trap as described. Another way of guarding against syphonage is to make the trap so large that enough water will drain back from the outlet and sides of the trap to restore the seal. This is called a pot or cesspool trap. City plumbing laws in general require the venting of all traps, which should be done in all cases.

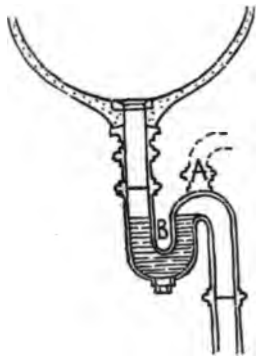


Fig. 44. S-Trap.

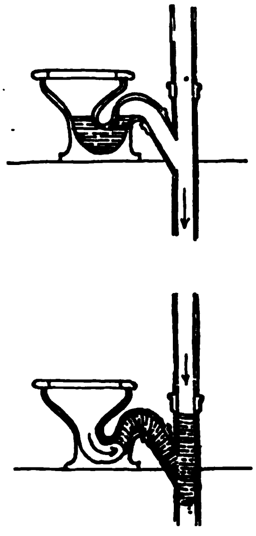


Fig. 45. Syphonage of Trap.

Testing. When the waste and air pipes are all in place and the connections for the various fixtures are put in, the whole system should be exposed to an effective test. The simplest and most efficient to employ at this stage is the water test called for by our specifications. This consists in closing all openings in the pipes and filling the whole system with water to the top. This may be done by attaching a hose at the bottom or filling from the top. The superintendent should be on hand to see that the water does not lower in the pipe after standing ten or fifteen minutes, when the system may be pronounced tight. If however, the water level drops it is evidence of a leak somewhere which must be sought out at once. In a tall line of piping the water pressure will be such that defective joints or sand holes in the piping will be discovered by a stream of water, or at least by the trickling of water down the pipe. Imperfect joints, in the cast iron pipes may be remedied by a more careful caulking, but the presence of sand holes can only be remedied by replacing the defective pipes which should be subjected again to the test until the system proves absolutely tight. After all fixtures are set and all connections made another test is usually made. This may be the "peppermint test" or the "smoke test". In the former test a vial of oil of peppermint, which is sold sealed for the purpose, is taken to the roof and the contents poured into the top of the soil pipe. A quantity of hot water is immediately poured in and the top of the pipe closed by stuffing in paper or rags. The vapor, charged with the odor of peppermint, is thus unable to escape and will penetrate the whole system.

All drain, air or waste pipes and connections are immediately examined and any odor of peppermint detected will be evidence of a defect which must be remedied. Great care must be taken in applying this test which should be done by separate parties, one outside and one inside of the house, and no direct communication should be held until the test is pronounced satisfactory.

Another method of applying the peppermint test is to close all vent pipes and vaporize the oil of peppermint in the receiver of a small air pump, and then force the vapor into the system under pressure. The receiver is provided with a gauge so that any leak will cause a fall in the mercury and can then be located by the odor of the peppermint.

The smoke test is required in our case and is done by closing the system as for the peppermint test and forcing into the pipes smoke from oily waste or some similar substance by means of a bellows. When the pipes are filled and a slight pressure produced it is shown by a float which rises and remains in this position if the joints are tight. If there is a leak the float falls as soon as the bellows are stopped and the leak may be located by the issuing of smoke from the joint. Special machines are to be bought for making these tests, which should be done in the presence of the architect or superintendent.

Fixtures. In general, the ideal of any kind of plumbing fixtures consists of a bowl, tub or closet in one piece, supplied by a sure and quick flow of water, and emptied by a simple and ample discharge. The superintendent should see that the quality and pattern are as called for by the specifications, that they are perfect in every respect and set up in a workmanlike manner. In regard to closets there are several types from which to choose. The simplest of these is the "short hopper". This consists of an earthenware bowl (Fig. 46), and a trap, the latter being sometimes made of earthenware, and often a lead or iron trap to which the bowl is bolted (Fig. 47), the contents being washed into the soil pipe by a discharge of water all around the top rim, which is curled over and perforated or brought to a narrow opening. An improvement of this form known as the "wash down" closet (Fig. 48), in which a deeper trap and a larger water area is formed than that made by the regular hopper and trap, is a well-known pattern. This closet requires a large flush of water to remove the contents and is somewhat noisy on that account. To overcome this and to assist in the discharge as well, there has been invented what is known as the "syphon-jet" closet. (Fig. 49.) In this closet a small inlet in the bottom of the basin is connected with the flush pipe, so that when the bowl is flushed a jet of water shall be projected upward which assists in removing the contents of the basin and also in filling the outlet, which is contracted somewhat, in order that the flow of water may fill it completely and produce on a large scale the vacuum as previously described in relation to the S-trap, so that the pressure of the air upon the water in the basin helps to push out the contents. An objection to the jet is found in houses which are to be left unoccupied during the winter, since the water which is to be thrown out to form the jet remains in the bowl even when the trap has been

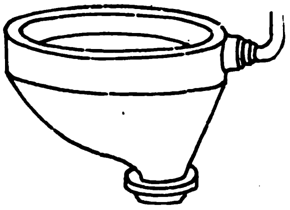


Fig. 46. Hopper.

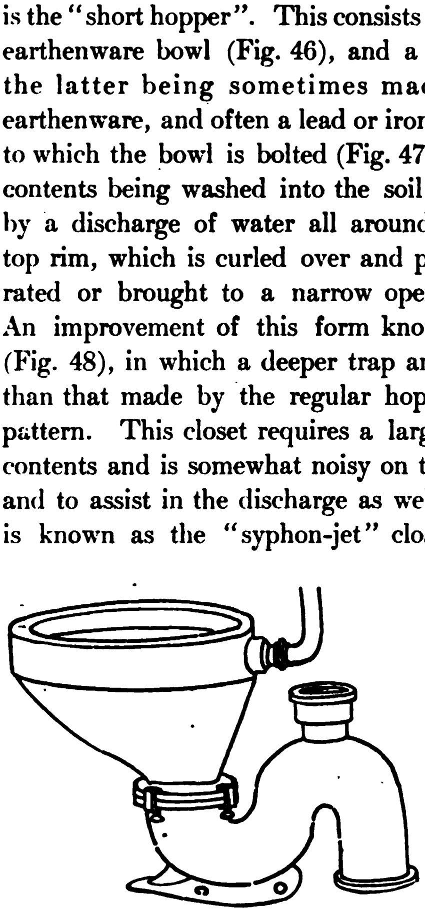


Fig. 47. Hopper and Trap.

emptied, and requires especial attention. Another form of syphon closet produces the syphonic action without the jet by making a sudden turn in the outlet pipe, which causes the flush of water to completely fill the pipe and produce a vacuum with the same result as described. A type of closet called the "washout" closet was formerly much in vogue (Fig. 50), but it is not so positive in its action as the others described, and is less popular than formerly.

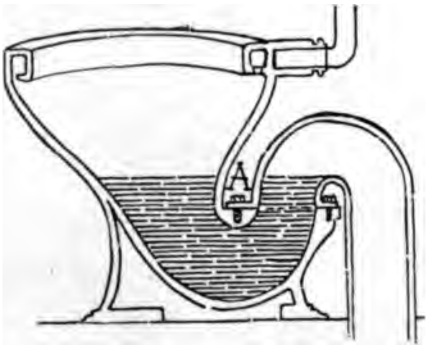


Fig. 48. Wash-Down Closet.

Connections and Vents. Close attention should be paid to the connection between the closet and the soil pipe as this, except in the case of the hopper closet with metal trap, will come on the sewer side of the trap and must be made absolutely tight. Some of the best closets are constructed so that the connection shall be under water and any leak will at once betray itself. (A, Fig. 48.) Another patented connection retains about a pint of water in a ring where the connection is made, which will appear upon the floor if the connection is not perfect. The connection from this point to the soil pipe is usually made with a lead bend, which is caulked, by means of a brass ferrule, into the soil pipe.

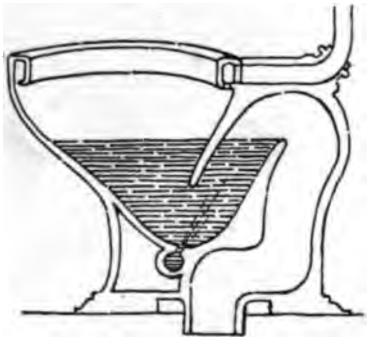


Fig. 49. Syphon-Jet Closet.

All closets should be provided with a "local vent" outlet, a tube extending from the upper part of the basin to which a galvanized pipe may be attached and carried to the nearest warm flue for the ventilation of the basin, and all traps, especially where the discharge of higher fixtures may create a vacuum in the soil pipe, should be vented to the main stack of vent pipes.

Tanks and Flushing. The usual way to provide for a sure supply of water to flush out the closet has been to fit up over it a copper-lined tank supplied from the house service and regulated by a ball cock. The operation of flushing the closet is performed by pulling a chain or rod which raises a heavy plug from the upper end of the flush pipe and causes a more or less prolonged flow of water, when the plug again seats itself and the tank is refilled. (Fig. 51.) This simple operation in itself is productive of considerable noise and there are on the market many devices aimed to secure an ample flow with a minimum of noise. Another form of tank, and especially valuable where height is limited is called the "low down" tank. (Fig. 52.) In these the loss of power of gravity is made up by enlarging the supply and they are very satisfactory in their operation. A newer and increasingly popular form of flushing closets is by means of a valve which delivers a quantity of water directly from the general service, or from a special supply, and then closes automatically.

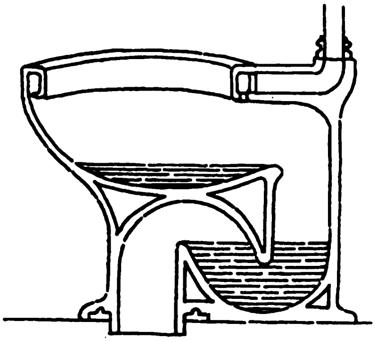


Fig. 50. Washout Closet.

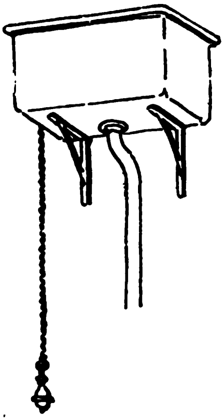


Fig. 51. Common Tank.

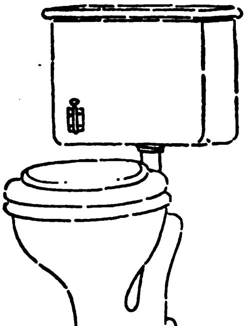


Fig. 52. Low-Down Tank.

These valves are put upon the market by different dealers under various names, but are about all identical in principle. These valves have been formerly used where many closets are to be supplied or where the presence of any kind of tank is undesirable, but are coming more into favor for general usage.

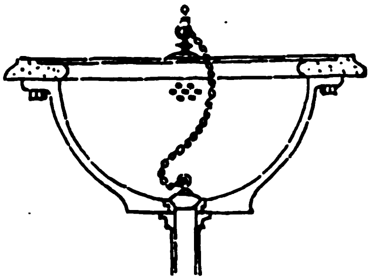


Fig. 53. Plug and Chain.

Bowl and Tub. Not so much choice is to be found in the selection of bowls and tubs. Of the former the main difference is to be found in the overflow and waste. These appliances have advanced from the old fashioned plug and chain (Fig. 53), to the most advanced form of outside connections (Fig. 54), which is the pattern called for by our specifications. In the choice of a modern tub we may range from the ordinary roll-rim enamelled iron tub with painted exterior, which is excellent in all respects, through the various stages of finish and pattern to the solid porcelain tubs of luxurious design and finish. Porcelain goods are marketed in three grades with a great variation of price, from A, which is absolutely perfect in every respect, to B, which allows of slight imperfections and C, which is more imperfect, but sound and whole.

Enamelled iron goods are put on the market in two grades, "guaranteed" as to the enamel, which goods will be replaced by the manufacturer if the enamel does not remain perfect for a reasonable time, and "unguaranteed," which are taken at the purchaser's risk.

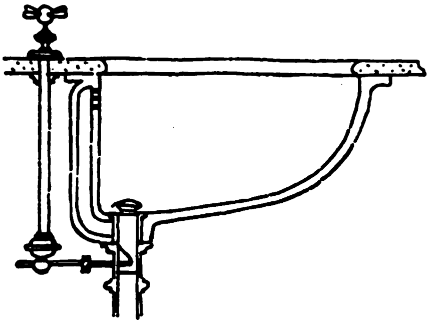


Fig. 54. Outside Connection for Basin.

Cocks. The choice of cocks for the fixtures will lie between two kinds, the "ground" cock and the "compression" or "screw down" cock. The former consists of a ground plug through which is put a hole in line with the aperture, which is opened and closed by turning the plug so that the hole is in the range of the bore when open, or across the bore when closed. (Fig. 55.) Although simple and positive in action this form of cock is open to the objections that when in constant use the plug and socket will become worn, especially if the water contains any sand or grit, and if used only occasionally the adjacent parts become corroded and the plug will refuse to turn. A better form is the compression cock (Fig. 56), in which the spindle is screwed hard down upon the opening and is given a perfect contact by means of a washer of leather or composition, which can be easily renewed when it becomes so much worn that it allows the cock to leak. In general the cocks in bath room and china closets should be nickel plated, while the cocks and piping of kitchen and laundry will be more satisfactory if of polished brass. The cold water cock of these fixtures, and of the pantry sink as well, should have a hose nozzle termination.

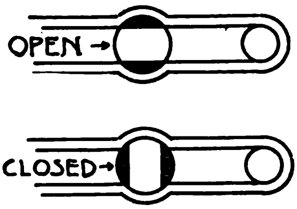


Fig. 55. Ground Cock.

When the plumbing fixtures have been installed, the superintendent should see that they are properly protected, from accident or abuse, until the owner is ready to assume the care of the house.

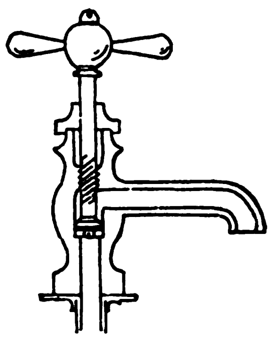


Fig. 56. Compression Cock.

HEATING.

While the plumbing work is being done, another set of men have been putting in the heating apparatus.

Selection. The selection of the heating apparatus will depend upon local custom, expense and personal preference. Three principal methods present themselves with some special features to recommend each. These are the hot air furnace, the hot water heater, and the steam boiler. The simplest and least expensive in the cost of installation is the hot air furnace (Fig. 57), which also has the merit of introducing a continuous supply of warmed fresh air into the house. Next in cost of installation, is the system of direct steam heating; when once installed the cost of maintenance is less than the hot air furnace. This is due in part to the fact that in direct steam heating, the already tempered air of the rooms is simply raised to the desired warmth, and fresh air must be supplied by other means. This system has the advantage of being more easily adapted to the heating of distant parts of the house, and is positive in its action at all times.

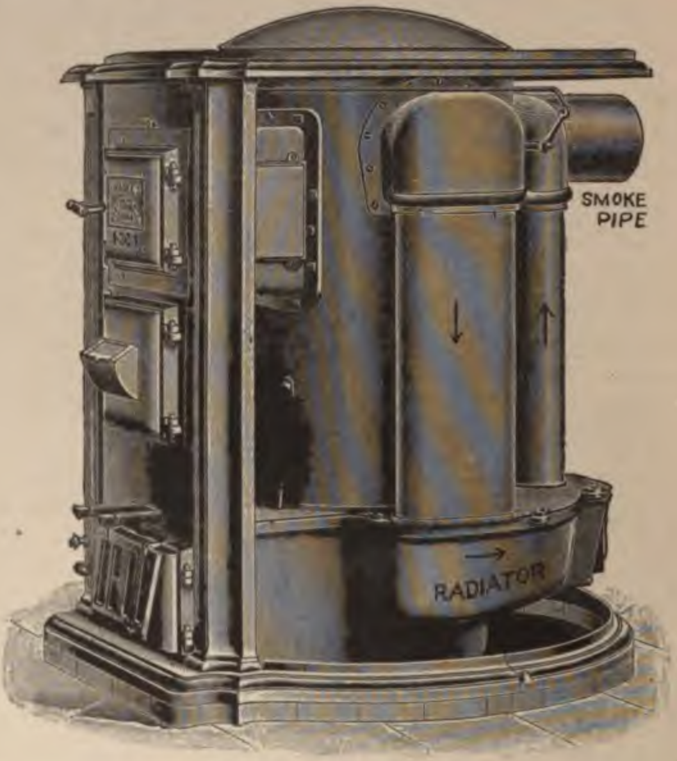


Fig. 57. Indirect Draft Furnace.

Of greater cost to install, but with some advantages in maintenance, is the system of direct hot water heating. This is similar to direct steam except that hot water circulates throughout the system instead of steam and herein is one advantage due to the ease with which the temperature can be regulated.

Steam is generated by the raising of water to a temperature of 212 degrees F., and so the radiators of a steam heating system are always at about the same temperature, and regulation of the heat is secured by shutting off and turning on the steam at intervals, while with hot water the radiation will be regulated by the temperature of the water which is in circulation all the time. This is a distinct advantage in mild weather as it allows of a smaller fire and a corresponding reduction in the consumption of fuel.

In the selection of a heater the most important thing is to be sure that the heater, whether hot air, hot water or steam, is amply large enough to do the work. Our client has decided to heat his house by means of hot air and we have advised him to put in a furnace which contains a large air chamber in order that the rooms may be supplied with a large quantity of warm air, rather than a smaller quantity of intensely hot air.

Furnace. For economy of fuel we find recommended a furnace of the type known as *indirect draft.* In this type the heated gases are ordinarily obliged to pass downward to a radiating chamber at the base and thence upward again before escaping into the chimney, thus giving off a large proportion of their heat. Among other points to be considered in the selection of the furnace is the grate, which should be of a pattern that will allow of easy disposal of the ashes and clinkers without much disturbance of the fire. The construction of the fire pot is of great importance in the choice of the furnace, and here the choice will lie between a heavy cast iron pot, and a thin wrought iron or steel pot with a lining of fire bricks. The cast iron pot has the advantage of continuing to give off considerable heat when new coal is put on, while the brick linings allow the furnace to cool off more while the fire is dull. Other points to be desired are a large combustion chamber, as the space above the fire is called, and ample heating surfaces, so arranged that they will not become deadened by soot.

Cold Air Box. The furnace, which has been selected besides these points, on account of the smoothness of its castings and the evidently workmanlike construction of its joints and working parts, is made to set over a circular pit into which the cold air box runs. An important feature is the size of the cold air box which should be of a capacity nearly equal to the combined area of the piping. About one-sixth less is the close rule as the cold air will expand about that amount on becoming heated. Unless the supply from the cold air box is ample there will be danger that the long pipes will draw from the shorter pipes, or that the general flow will be weak and irregular. The opening of the cold air box is usually placed on the north or west side, as the coldest winds generally come from those directions, but a better way is to carry the cold air box completely across the cellar with a connection to furnace at right angles, so that the furnace may draw an equal supply without regard to the direction of the wind. By this means we shall avoid the very disagreeable feature which all who have heated by furnace in the usual way will have experienced, of finding that when the wind is high from the side where the cold air is taken, the chances are that the air will be driven so rapidly through that it does not get sufficiently heated, but comes in cold gusts from the registers. On the other hand, when the wind is strong from the side opposite the single cold air opening, the suction from the lee side of the house will often cause the air to flow down the registers and out of the cold air box, where there is danger of the already heated air becoming hot enough by reheating to set the cold air box on fire, if it is of wood. To guard against a possibility of this, it is best if possible to make all air ducts of galvanized iron, which is safer but unfortunately more expensive. In certain localities this metal construction will be required by the building laws, and is to be recommended in all cases.

Location. In locating the furnace care should be taken that the pipes are of about the same length, any differences should be made in favor of pipes running north or west. The smoke pipe should be run as directly as possible and should never come nearer than eight inches to the floor beams overhead. Care must be taken where the pipe enters the flue that the connections are tight, and that the pipe is not pushed in so far that it cuts off the area of the flue.

Supervision. Beyond seeing that the apparatus, the piping and the registers are ample in size and properly heated, the superintendent should watch carefully to see that there is no danger from fire. All pipes which are run in concealed places should be double, or at least well protected by bright tin or asbestos covering and the use of wire for lathing over them. The furnace should have over it, a circular shield of metal or else plastering on wire laths for an ample space on the ceiling. In running the pipes, sharp bends and sudden contraction or distortion of the pipes must be avoided, and free entrance of pipes to the register boxes must be provided in all cases. The practice of topping pipes or running one pipe to supply two registers, is productive of continual annoyance, as it is almost certain that one register will get the greater part of the heat at the expense of the other. The registers should always be set in borders of slate or soapstone, or in the iron rims which are provided and they should be free in action and tight when closed.

STEAM HEATING.

Another efficient method of heating for country houses, is by direct steam radiation. This consists in circulating steam through radiators or coils placed directly in the rooms and halls to be heated. This may be done under high or low pressure, but the low pressure gravity return system is generally used for house heating, a pressure of from two to ten pounds being rated as "low pressure".

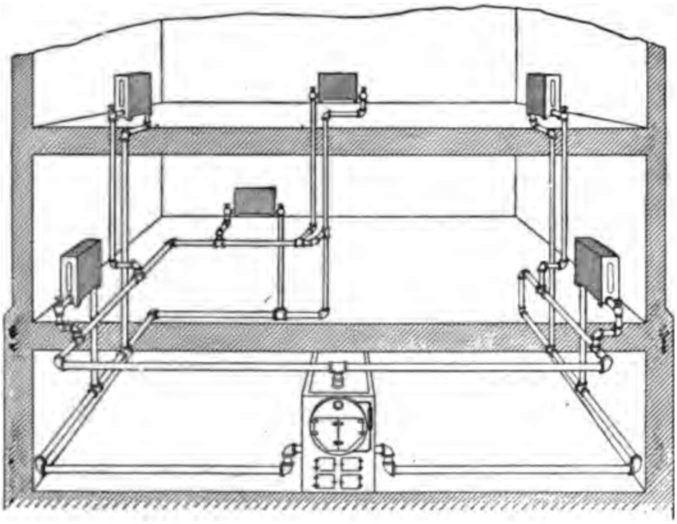


Fig. 58. Two-Pipe System.

Piping. Three systems of piping are used in this form of heating called the "two-pipe system", the "one-pipe relief system", and the "one-pipe circulating system". In the two-pipe system the main pipe is taken from the top of the boiler and carried by branches along the cellar ceiling, pitching gradually down until all of the "risers" have been taken off, when it drops down and returns with a slight pitch to the boiler, below the water line. (Fig. 58.) This is called a "wet" or "sealed" return. Sometimes the return pipes are run overhead and this is called a "dry" return. This dry return is more productive of noise in the pipes than the wet return and is not so often used. In either case one set of pipes is run from the main supply pipe in the cellar to the different radiators and another pipe carries the condensation from the radiators to the return pipe. This requires two sets of pipes, valves, and connections and is more expensive than the one-pipe systems which are generally used.

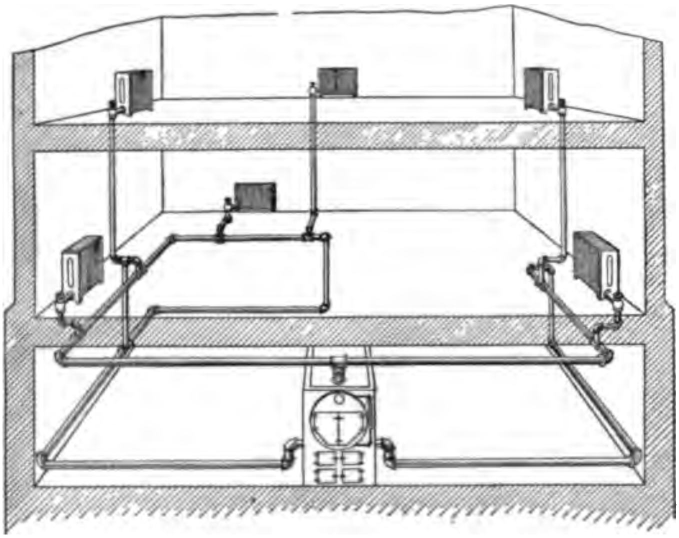


Fig. 59. One-Pipe Relief System.

One-Pipe Relief System. In this system the arrangement of the cellar piping is the same as in the "wet" return previously described, but the supply to the radiators consists of but one pipe, taken off from the main supply in the cellar, the steam flowing in, and the condensation draining out, through this single pipe to the main and thence through frequent "drip pipes", to the return pipe, near the cellar floor. (Fig. 59.) If the return pipe in the cellar is run overhead, as in the "dry" return system the drip pipes should be connected to the return main by a loop falling below the return, thus forming a trap and preventing the steam from flowing directly into the return.

One-Pipe Circuit System. In this system the main supply is carried to the ceiling of the cellar and there makes a complete circuit of the building at a downward pitch and connects again with the boiler below the water line. (Fig. 60.) From this circulation pipe single risers are taken to the radiators, and the condensation flows back through the same pipes to the circulation pipe, and is carried along with the steam and returned to the boiler. This circulation pipe should be of large size and with a good pitch all the way.

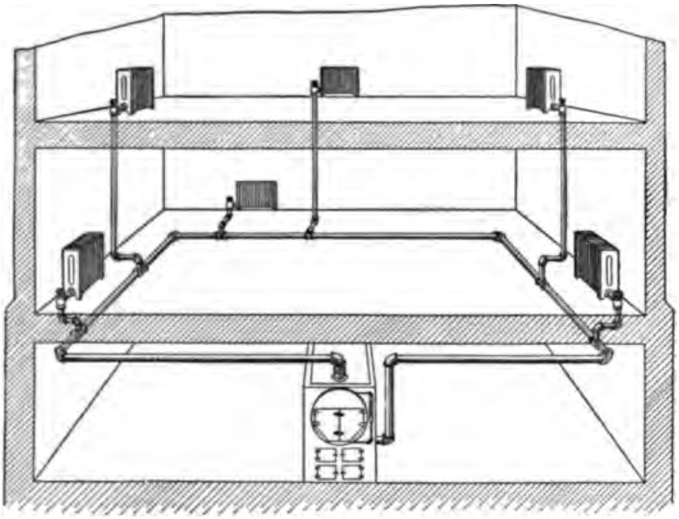


Fig. 60. One-Pipe Circuit System.

In all single-pipe systems the piping must be larger than in the double-pipe systems, as the steam and the returning water are flowing through the pipes in opposite directions at the same time. This may be obviated by running a single riser to the top of the building and then branching out to supply the different radiators by single pipes run back to the basement. In this case the steam and water flow in the same direction and for large work this is often done.

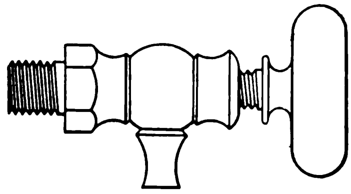


Fig. 61. Air Valve.

Valves and Connections. Careful examination should be made of the valves and pipe connections to see that they are efficient and properly applied. Many styles of valves are available, and only well known or well tested patterns should be allowed. Of air valves for steam radiators the simplest form is the "pet cock", a screw valve operated by hand (Fig. 61), but there are several forms of automatic valves on the market which will allow the escape of cold air from the pipes, but are instantly closed as soon as affected by the hot steam. This is done by the expansion of a metal part which closes the orifice.

Radiators. The form of steam radiator in general use is the cast iron radiator (Fig. 62). This consists of a series of loops connected at the bottom. The steam entering at one end forces the air out of the air valve placed about midway of the last section. The two end sections are of the same internal patterns as the others but are cast with legs.

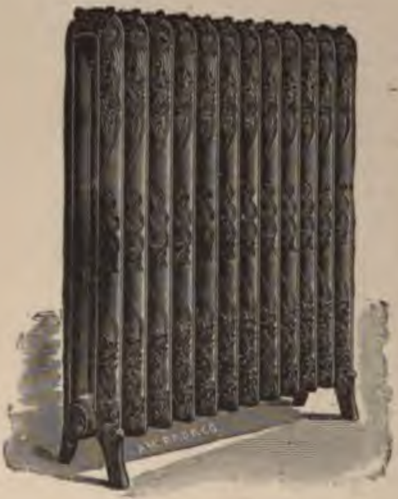


Fig. 62. Cast-Iron Radiator.

Pipe radiators (Fig. 63) are often used and, where design is not an object, the use of circulation coils of piping may be permitted.

Boilers. Many of the ordinary types of steam boilers are used for steam heating and in addition to these there is a cast iron sectional boiler which is used for dwelling houses to a great extent. (Fig. 64.) The main thing is to select some well-known type and to see that it is carefully set, with all attachments, which will usually be described in the contracts. This method of direct radiation lacks the advantage of the introduction of fresh air into the house, but, if care is taken to provide for this by other means, it is economical and positive in its action. The main point to be seen is that heater, pipes and radiators are amply large, and that the radiators are well placed and supplied by carefully graded pipes, tightly and neatly connected. Cellar pipes should be covered with some of the patented sectional pipe coverings, and radiators and all pipes which are exposed to view may be coated with bronze of a desired color. Where pipes pass through floors or partitions they should be protected by sleeves three-quarters of an inch larger than the pipes, and collars should be neatly placed around the pipes at the floor and ceiling, or on each side of the partition.

HOT WATER HEATING.

Another method of heating is by a similar application of direct hot water radiation. This consists in circulating hot water through radiators, which are placed in the rooms as in the case of direct steam heating. The hot water is conducted from the main heater in the cellar through the pipes and radiators, and the air is warmed by the direct radiation from these sources. The principle of this circulation is found in the difference in density and volume between hot and cold water. Water is at its greatest density at about 39 degrees F. When heated its density decreases and its volume increases, so that as soon as the fire in the boiler is started the circulation begins, and the water becoming lighter flows up through the pipes and radiators giving off its heat, until becoming colder and heavier it flows back through the return pipes to the heater. This process is continuous as long as

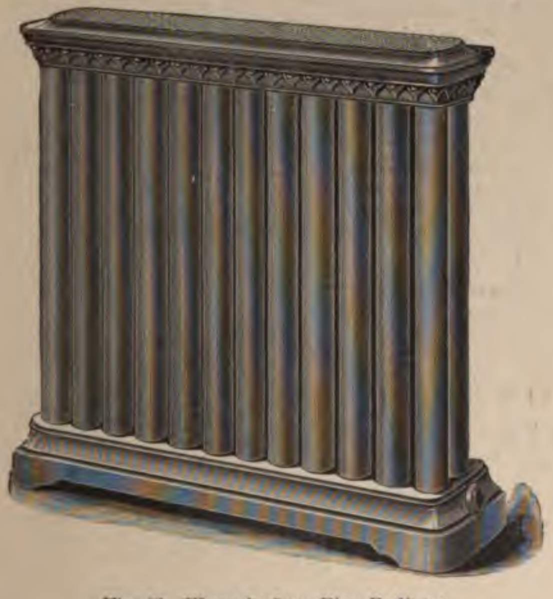


Fig. 63. Wrought-Iron Pipe Radiator.

any heat is applied to the water in the boiler, the velocity of flow depending upon the difference in temperature between the supply and return, and the height of the radiators above the boiler.

Hot Water Piping. The system of hot water piping consists of a free circulation of water from the heater to the radiators and back to the heater again. The supply pipe is taken off at the top of the heater and main and branches are run with an incline upward, the return pipes being parallel to these and connected with the bottom of the heater. Risers are taken off the tops of the mains and return pipes connected to the return mains in a like manner. (Fig. 65.) As this system depends upon the force of gravity to keep up its circulation an expansion tank (Fig. 66) must be provided, high enough above the highest radiator to insure free circulation, and the pipes should be run so that any radiator may be shut off without interfering with the general circulation. This tank should be supplied with a

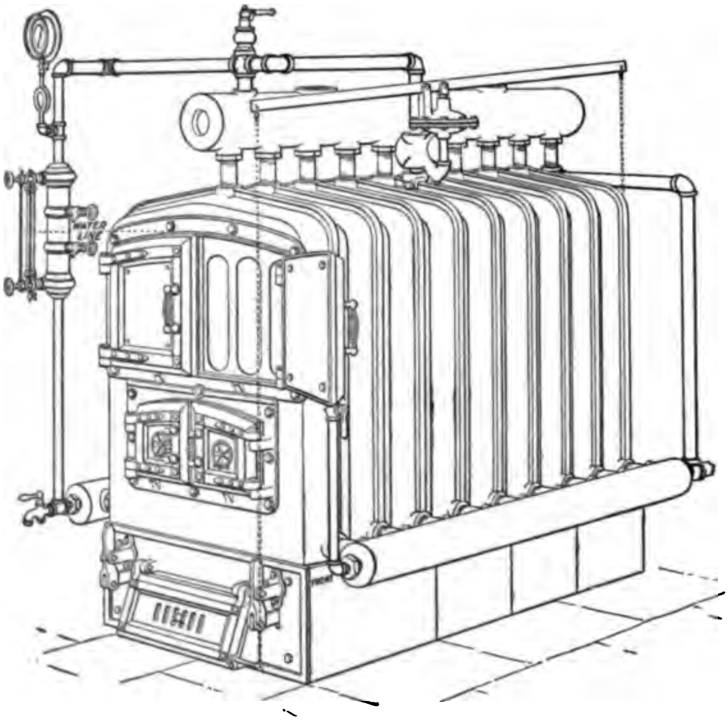


Fig. 64. Cast-Iron Boiler.

glass gauge and an overflow to some convenient place, and an open vent pipe should be taken from the top. The connection from the heating system enters at the bottom and an automatic connection should be made with the main water supply. A water connection should also be made at the heater to be used when the system is first filled, as by this means the air is driven upward and discharged through the vent on the tank.

The expansion tank should be large enough to contain a gallon of water for every forty square feet of radiation.

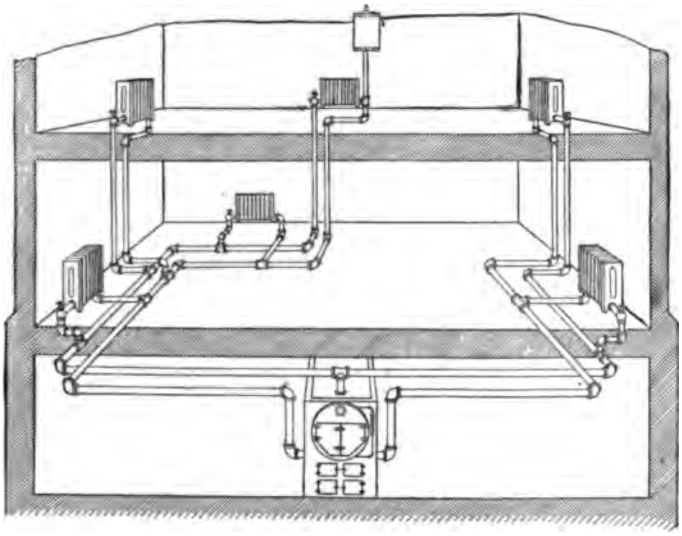


Fig. 65. Piping for Hot Water Heating.

Valves. Special valves are made for use with hot water radiators, the main advantage being a device for quick closing, a half turn being usually sufficient to open or close the valve. Connections with the radiators may be made at the top or bottom, the return pipe being always at the bottom. Only one valve is necessary to stop the flow of water through the radiator and this is put on the supply pipe, the return connection being made by a union elbow.

The ordinary "pet cock" is generally used for an air valve, but there are several forms of automatic valves which are operated by a float which allows the air to escape when the water line is lowered but closes upon the flowing in of the water.

Hot Water Heaters. The heater differs from a steam boiler mainly in the omission of the space allowed for steam, the hot water heater being filled with water in circulation instead of steam, so that it is essential that the heat should strike the surface in such a manner as to increase the natural circulation.

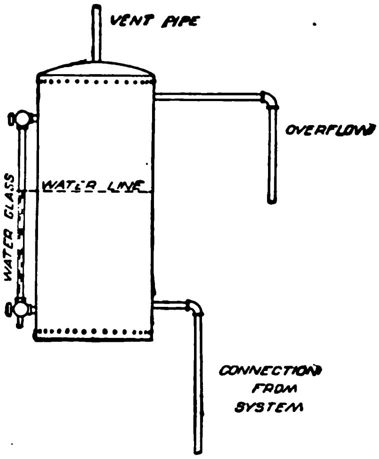


Fig. 66. Expansion Tank.

Radiators. Radiators for use with hot water differ from the ordinary steam radiators in having a passage at both bottom and top, as shown in the illustration, Fig. 67. This is necessary in order to draw off the air which gathers at the top of each loop. These radiators may be used for steam as well as hot water and are arranged for either top or bottom connections. Sometimes the piping is so arranged that, instead of running pipes to each radiator from the heater, a single riser is carried up to the expansion tank from which pipes are run to supply the drops to which the radiators are connected. (Fig. 68.) In this case the radiators are supplied at the top and emptied at the bottom, and as the air in this system rises at once to the expansion tank and escapes through the vent, no air valves are required on the radiators.

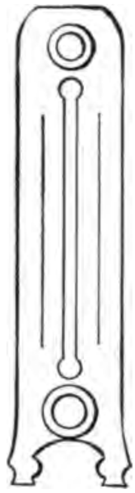


Fig. 67. Pipe Connections. Hot Water Radiator.

Other methods of heating are by indirect steam, indirect hot water, and a combination of hot air and steam, and the same general principles will apply to these methods as to those which have been considered. The indirect application of steam or hot-water is the system by which fresh air is brought to each register, after being heated by passing over a coil of steam or hot water pipes, and while it is the most satisfactory of all means of heating, the expense of installation and maintenance is a bar to its employment for ordinary country or suburban house heating.

INSIDE FINISH.

After the furnace or heater is set and the plastering and concreting are thoroughly dry, the inside finish of the house may be put up. The door frames, which should have been all ready, will first be set and great care must be taken to see that these are set square and plumb. If a single rebated frame is used (Fig. 69*a*), the superintendent must see that it is set with the rebate on the proper side of the partition. Our specifications call for all inside door frames to be double rebated as at *b*, which not only does away with the necessity of this precaution, but has the merit of allowing the doors to finish at the same height and width on both sides of the partition and also allows of the door being hung on either side.

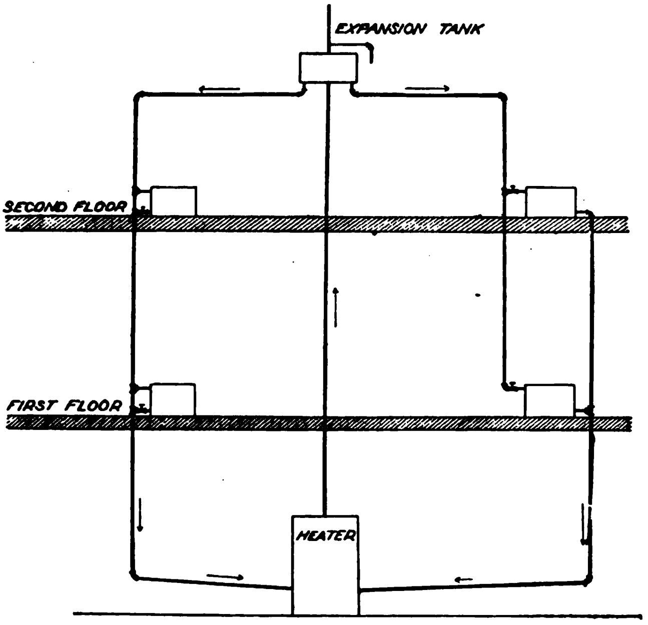
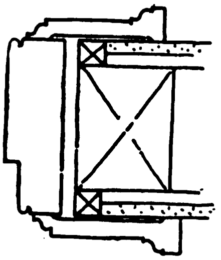


Fig. 68. Piping for Overhead Distribution.

Architraves. When the door frames are set the next operation will be to set the door and window architraves, called in some localities door and window "trim", although "casing" is perhaps the more common term. There are two principal methods of casing a door or window; by the block casing (Fig. 70*a*), or the mitred casing.

(*b.*) The block casing is the simpler and less liable to be disfigured by shrinkage, as the joints are all straight across the casing, and, as this will not shrink endways, the joints do not open. The mitred finish is neater in appearance but can be used only with thoroughly kiln-dried wood, as any shrinkage will cause the joint to open. Architraves of either kind are usually hollowed out on the back as shown, to allow each edge to fit closely to the frame and the plaster, and avoid danger of displacement by possible warping or twisting of the casing or ground. Plain blocks to the height of the base are often put at the bottom of the door casing, called plinth blocks. (Fig. 71.)



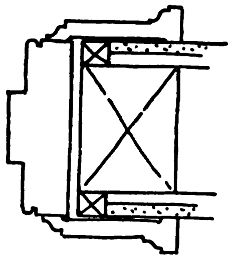
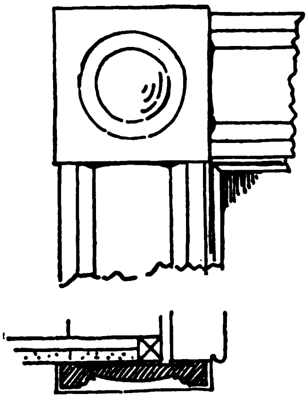


Fig. 69*a*. Door Frames. Fig. 69*b*.



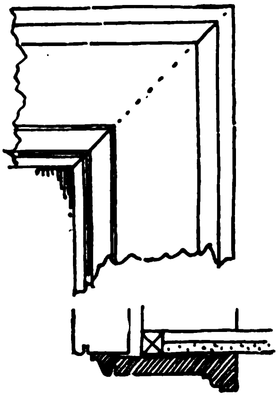


Fig. 70*a*. Door Finish. Fig. 70*b*.

The superintendent should watch to see that all joints are carefully done, that margins are even on all sides, and that the mouldings are securely nailed. The mouldings must be scraped or sand-papered, or both, to remove all traces of the milling or planing, the effect of which is to leave marks upon the wood, and these imperfections will appear more noticeable when varnish has been applied. No casings should be spliced, although long horizontal mouldings such as bases and wainscot mouldings will have to be spliced, and care should be taken to see that this is neatly done.

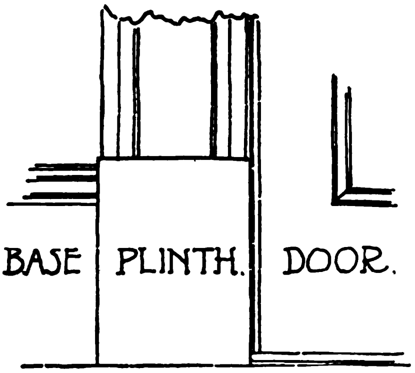


Fig. 71. Plinth Block.

For painted work it is customary to nail the finish to the walls and frames with finish nails, well set for puttying. The nails should be driven in the quirks of the mouldings as much as it is possible. For hardwood finish the members should be glued together at the shop as far as is possible and no more nails used than is absolutely necessary. Wainscoting, if panelled, should be put together at the shop in as long lengths as possible, and painted on the back before setting, and angles and corners should be rebated together. (Fig. 72.) The projection of the dado cap as well as chair rails should be studied in connection with the architraves to be sure that they are coming together in a satisfactory manner. Where a dado is used the line of the window stools will sometimes be made the top of the cap, and in this case especial care must be taken that the window frames may finish at the same level. Where a chair rail only is employed it is generally set about three feet above the floor.

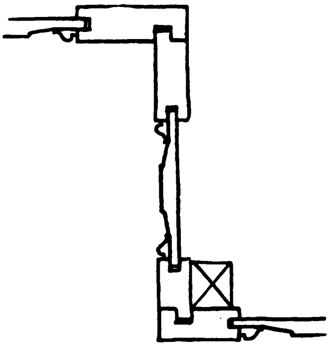


Fig. 72. Rebated Corner.

Bases and chair rails which run between doors and windows can generally be obtained without splicing. Picture mouldings if set any distance below the ceiling will need especial attention to be sure that they are run level and are securely nailed.

Stairs. Close attention must be given the stairs to secure a satisfactory result. In the beginning the stringers must be examined to see if they correspond to the plans in the number of steps, and that ample head-room is provided where one flight of stairs comes over another. The plans will show the number but not the height of the risers, as this can only be determined by dividing the whole height from top to top of floors, by the number of risers shown. This should have been laid out to give for ordinary stairs a rise of about seven and one-half inches, and the sum of the tread and rise together should make for an ordinary house staircase between seventeen and seventeen and one-half inches, so that with seven and one-half inches for the rise, the tread should be nine and one-half or ten inches. Another rule is that the product of the rise and tread should be seventy to seventy-five inches, that is, if the rise is six inches, the tread should be eleven and two-thirds to twelve and one-half inches. For stairways where the space is limited "winders" may be inserted (Fig. 73), but where there is ample room, it is well to avoid them.

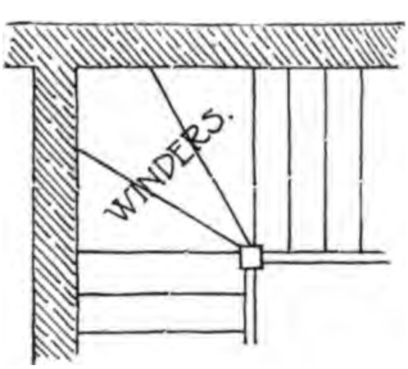


Fig. 73. Winding Stairs.

The question of head-room is an important matter and one that is not easily foreseen, so that often costly stairways which are otherwise well conceived are sometimes spoiled by too close head-room. With floors of the thickness of ordinary dwellings the well-room should extend over at least thirteen risers, and where one flight comes directly over another, seven and one-half feet in the clear, over the face of the riser, should be allowed.

In the construction of stairs methods differ somewhat. In New England it is customary to build the finished work of the stairs upon the rough stringer, piece by piece. The treads and risers are brought from the shop all fitted and are nailed into place, the risers are first put on, grooved at the bottom to receive the tongue of the tread, and the tread grooved on the under side and fitted over a tongue in the riser. (Fig. 74.) A small moulding is then put in the angle under the edge of the tread, and this finish is carried around the end of the step in "open string" flights, where the tread appears at the end. (Fig. 75.) The inside or wall edges of both tread and riser are grooved on the line of the base, the lower edge of which is scribed to the outline of the steps and cut away on the back to form a tongue, which, after the steps are all in place, is driven into the grooves, the stair nosing being cut away. This is necessary to prevent the appearance of a crack along the whole wall end of the stairs, which will invariably appear on account of the shrinkage of the stairs and base, but unless carefully watched it is likely to be omitted, as the fitting and tongueing of the base is a difficult matter. In the second or "English Method" the finished stairs are put together at the shop and brought bodily to the building and fitted to the rough stringers. In this construction the wall ends of the steps are grooved into the base or wall stringer and wedged and glued. The outer stringer, if a close or curb string (Fig. 76), is tongued and fitted into the treads and risers. This method of "housing" is also sometimes used when the stairs are built at the building. One objection is found to the English method where the stairs are plastered underneath, in that there is no good chance to fit and wedge the finished steps to the rough work, but where the underside of the stairs are panelled there is ample opportunity to wedge the work solid, which is necessary to prevent squeaking, a very disagreeable thing in a staircase. In open string stairs, before the end nosings are put on, the treads should be dovetailed at the end for the balusters, and when these are fitted

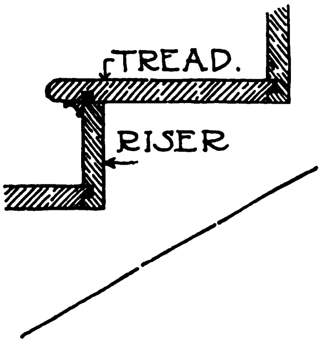


Fig. 74. Tread and Riser.

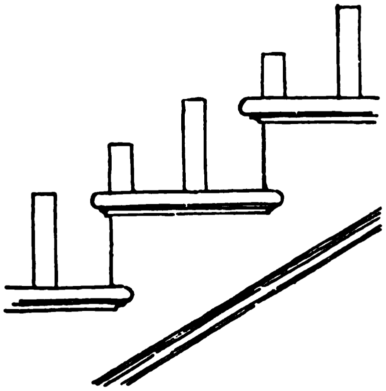


Fig. 75. Open String.

in, the nosing will make them secure. This should be done in all good work, although the general practice is to nail the balusters at the bottom.

Against the sloping rail the balusters may be securely nailed, but the rail must be secured to the posts by bolts made for the purpose which are let into the end of the rail. (Fig. 77.) Where the stair rail comes against the wall it is better to put a half-post than to allow the rail to run into a plate, which will be done unless the half-post is shown or specified. The erection of the stairs should be closely followed by the superintendent, as there is a great opportunity to slight their construction. If put together at the building, the rough stringers should be carefully verified to see that the treads are level and the risers all equal. The cutting of these stringers is a matter of great nicety, and mistakes are often made which the workmen will sometimes try to remedy by tipping the stringer backward, if it is too long, or forward, if too short (A, Fig. 78), or by reducing or adding to the top and bottom riser (B). This should be watched for and never allowed, as a slight difference in the height or level of the steps is a source of danger. If the English method is used, especial care must be taken to see that the finished work is securely blocked and wedged.

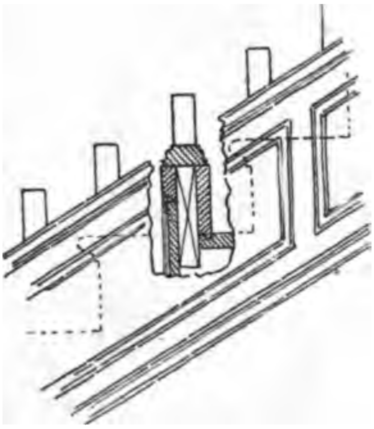


Fig. 76 Closed String.

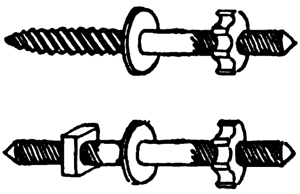


Fig. 77. Rail Bolts.

Windows. As a part of the finishing of the inside of the house will come the adjustment of the sashes and doors. The sashes are held in place by stop beads, which are strips of wood usually one-half an inch in thickness and of varying widths, according to the thickness of the sashes and of the walls. (Fig. 79.) These stop beads should always be secured by screws, as it will sometimes become necessary to remove them to adjust or replace the sashes. Special screws are sold for this purpose, if desired, which have a washer with a horizontal slot, which will allow of the slight adjustment made necessary by the swelling or shrinking of the sashes, by simply loosening the screws. Before applying the stops the sashes must be carefully fitted and balanced, and as they will vary somewhat in weight, the matter of a perfect balance will require close attention. The superintendent should see that each sash is so balanced that there will be no great effort needed to raise or lower it, and no danger of its banging by reason of too much or too little weight. He should closely examine the hardware to see that it is as specified and is carefully put on. Sash fasts are often badly set and each one must be tried to see that it works properly and easily. Pulleys should be carefully inspected to see that they are as specified. These will probably have been already set in the window frames when they were received, and unless the contractor has paid especial attention to them they are very likely to be of an inferior order.

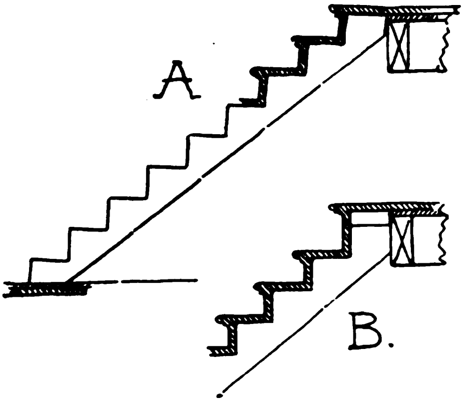


Fig. 78. Stair Stringers.

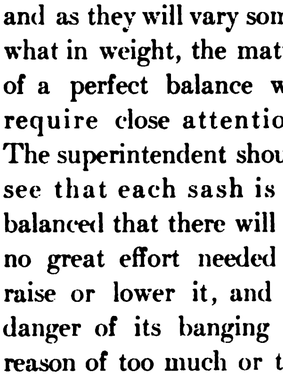


Fig. 79. Stop Bead.

The difference between a *plated bronzed* face and a *solid bronze metal* face is often overlooked, and the bearings will be inferior if not carefully examined. A steel axle pulley may be used for ordinary work, but for better service a turned or milled axle is preferable.

For hanging the sashes, cords, chains and metallic ribbons are used, but for the ordinary sizes of windows a good braided cord is perhaps to be preferred, this depending upon local custom. The size and particular brand of cord should be specified and care taken to see that this is furnished. The leading manufacturers have adopted a copyrighted device of a spot or name which appears at short intervals upon their cord and if noted will prevent any other being substituted. For large sashes with no vertical bar, such as are shown in main rooms of our house, sash lifts should be used. These are metal fixtures applied to the lower or side rims of the sashes to afford a hold for the fingers when raising the sash. In windows as wide as shown, with no vertical bar, the usual habit of starting to raise the sash by lifting up on the middle rail will result in loosening the putty and springing up the rail so that lifts are necessary. These may be of the ordinary hook shape, or may be a metal slot let into the lower sash. (Fig. 80.) Casement or swinging windows and transoms will require special fittings, of which there are a great variety, each designed to supply a special need.

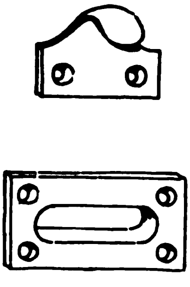


Fig. 80. Sash Lifts.

The main thing to be observed is that the appliances are as simple as possible and that the moving parts are noiseless and well adjusted.

Doors and Trimmings. The last of the interior fittings to be applied are usually the doors. These are of two classes, "stock" doors and doors made to order. Stock doors are made in certain regular sizes, generally of pine, whitewood or cypress, and may be obtained at all times, of the dealers. Stock doors are made in three grades, A, B, and C, of which, doors of the first quality may be used for the inferior portions of good houses, but these, by reason of their being stored for a greater or less time, are generally not thoroughly dry and will shrink and twist when subjected to furnace heat. The second and third quality of stock doors are a very inferior article and should be used only for the poorest kind of work.

Custom-Made Doors. The doors of the principal rooms should be made to order. If of pine or whitewood they may be made solid but must be of kiln-dried stock and kept perfectly dry. The tenons should be made, as specified, with haunches (Fig. 81) and the panels put in without bradding or gluing, so as the allow them to swell and shrink without cracking. Hardwood doors are veneered upon a core of well seasoned pine and should be examined, upon delivery, to see that this is done and that the veneers are of the proper thickness. The veneers should be one-quarter inch on the face and at least three-quarters inch on the edges, to allow of fitting. If the panels are of great width they should also be veneered, with the grain of the core running at right angles to the grain of the veneer. Doors which are to show hardwood on one side and a painted finish on the other should be veneered on both sides to prevent warping, which may occur if one side only is veneered. In the design and selection of doors care must be taken that the panels are so divided that the lock, in its normal position, will not cut off the tenon of the rail but will come opposite a panel. (Fig. 82.) The rails of a door are always tenoned into the outside stiles, and if there is a middle stile it is tenoned into the rails (Fig. 83), so that the tenon at A is an important factor in the strength of the door and is often weakened or destroyed by being cut for the lock.

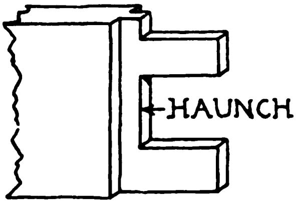


Fig. 81. Door Tenon.

Hardware of Doors. The hanging and fitting of the doors is a matter of great nicety and should be intrusted only to careful workmen. The hardware for an ordinary door will consist of the hinges, or "butts", the lock, knobs and escutcheon plates. Double doors will need in addition bolts for the standing part. Sliding doors will be hung on a "hanger", and the fittings must necessarily be flush to allow the door to slide into the wall. The specification of hardware for doors is often made a matter of an allowance, either at a certain price per door, or a sum is named to cover all the hardware of the doors, leaving the selection to the architect or owner. The latter method has been employed in our case and the architect's knowledge will become necessary in guiding the owner to a proper selection at the dealer's, rather than exercising an inspection of hardware at the building. In the selection of hinges the choice of material will be principally between solid bronze or brass, or plated,

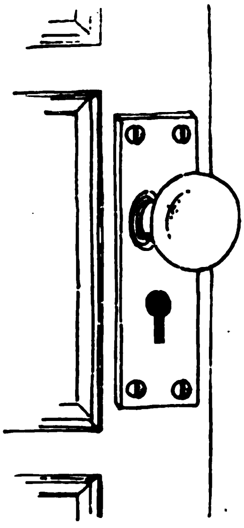


Fig. 82. Latch and Lock.

japanned or lacquered iron or steel. If of solid metal the best quality only should be used, with steel washers and bearings, as the soft metal will otherwise wear out from the swinging of the door. Modern door hinges are invariably made in parts, to allow of the door being removed without unscrewing the hinge, and this is accomplished by two methods, the *loose-joint butt* and the *loose-pin butt*. The former consists of a hinge made in two parts (Fig. 84), of which the part containing the pin is screwed to the door frame and the other part to the door; this allows of the door with its half of the hinge being lifted off if desired. With the loose pin butt (Fig. 85) the door is removed by drawing out the pin and slipping the hinges apart. Loose pin butts are becoming of more general use than formerly and possess some advantages. In the first place, the bearing surfaces are multiplied, and the pin being separate from the leaves allows of its being made of harder metal. Again, as either leaf can be fastened to the door or jamb, the same hinge may be used for a right-hand or a left-hand door, and the fact that the pin may be withdrawn allows of opening the door even when locked. This may sometimes be a disadvantage and should be borne in mind in using doors which open out of a room which must be made secure.

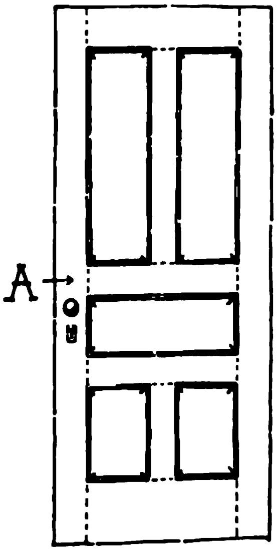


Fig. 83. Door Framing

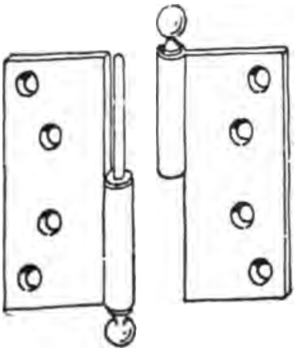


Fig. 84. Loose-Joint Butt.

Locks. The variety of door locks is so great that mention can be made only of some of the distinguishing features. According to their construction, locks are generally either "tumbler locks" or "cylinder locks", and according to their position on the door are "rim locks" or "mortise locks". Tumbler locks are the ordinary kind of lock operated by a long key (Fig. 86), and depend upon tumblers or levers which are raised by the key to an exact position before the bolt can be thrown. Cylinder locks consist of two cylinders, a small cylinder rotating inside of a larger one and only turning when a key of the proper shape and size is inserted. (Fig. 87.) Cylinder locks are not so easy to pick as tumbler locks, and there is less danger of an accidental exchange of keys, so that they are recommended for outside doors or wherever special security is desired. "Rim" and "mortise" locks differ only in the form of the case, rim locks being made to screw on the face of the door (Fig. 88), and mortise locks are let into the edge of the door (Figs. 86 and 87), the inside construction of both being the same. For ordinary house use, a three lever lock with brass or bronze face is good enough, but a cylinder lock may be used to advantage for the outside doors. The latch and lock will generally be found in combination and may be used with a long plate covering both knob and keyhole, or with a separate treatment of the keyhole by means of an "escutcheon". (Fig. 89.)

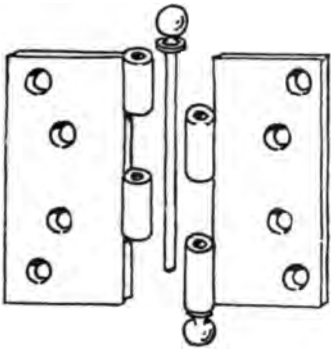


Fig. 85. Loose-Pin Butt.

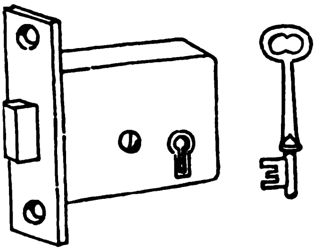


Fig. 86. Tumbler Lock.

Whatever treatment of escutcheon plate is adopted, the knobs and spindle will be the same and may be selected of a variety of materials and shapes. The cheapest knobs are of composition and are commonly called "mineral", "jet", or "porcelain" knobs. Wood finished in natural color is used to some extent, and glass as well. All of these are sold with bronze shanks and escutcheons. A better class of knob, and perhaps the most satisfactory of any, is the brass or bronze metal, either wrought or cast and finished in a variety of shapes and with a wide choice of finish.

Bolts. Of greater protection than locks on a door are bolts, which, being operated from one side only, are secure against picking. The simplest and least noticeable of these are the mortise bolts which set into a hole bored in the edge of the door and are operated by a knob or key on the face. Chain bolts are a protection in localities infested by tramps or undesirable intruders. These consist of a strong chain which is secured to the frame, and hooks into a slotted plate on the door, allowing the door to open only to the length of the chain, which cannot be dislodged except by again closing the door. (Fig. 90.)

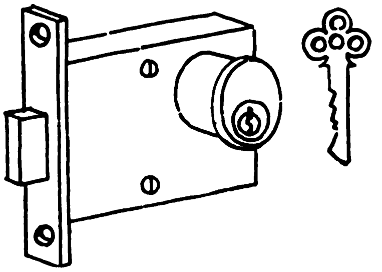


Fig. 87. Cylinder Lock.

Miscellaneous. The many small fittings such as coat hooks, drawer handles, cupboard latches and the like, should be selected for strength and utility rather than for effect, and are the most satisfactory in plain bronze metal or brass, and can be obtained of good manufacture and materials at moderate prices.

Inspection. The inspection of hardware is an important matter, whether it is furnished by the owner or the builder, as any changes made after fixtures are once applied are sure to produce defects of some kind. What purports to be bronze may be some baser metal skillfully bronzed or lacquered on the face. This may be detected by scraping the back with a knife or file. The faces of locks or bolts may be plated instead of being solid. Knobs may be poorly secured to the shank, and may lack proper washers to prevent rattling, and hinges may be furnished with no washers and will soon wear and creak. In the application of hardware also it is necessary to keep a sharp watch. Even in so simple a matter as putting on door hinges there is a right and a wrong way, for if the butts are not directly over each other, the door when opened will either swing back or forward.

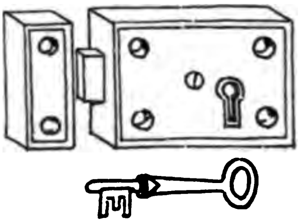


Fig. 88. Rim Lock.

Mortises must be accurately cut so that the locks will neither be loose nor be so tight that they cannot be removed if required. Roses or escutcheon plates must be put exactly opposite each other or else the spindle will bind in the lock. Knobs must be carefully adjusted by means of washers so that they will not slip back and forth. Striking plates for latches (Fig. 91) must be carefully centered and adjusted. While all hardware is usually packed with screws finished to match, the screws are often too small and their efficiency destroyed by being driven in with a hammer by careless workmen. This should never be allowed, but every screw should be set with a screwdriver. Good sized screws are especially important in door hinges, and the hinges themselves must be of ample size to allow the door to swing entirely back. The greatest vigilance is necessary to insure from defects of selection or application, and nothing will reflect more credit upon the superintendent than a good job of hardware.

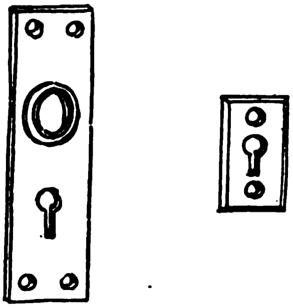


Fig. 89. Plate and Escutcheon.

Floors. When the inside finish has been put up, the rough under floors should be gone over and all holes and broken boards repaired and the floors cleaned off, ready to receive the finished floors. The laying of these, if they are of hardwood, is sometimes let out to a regular floor-layer, but in general this is done by the carpenter. For the carpeted rooms a good quality of spruce flooring not over four inches wide will be used laid with square-edged boards. If possible, the boards should be laid in one length, and if this cannot be done, the joints should be broken as often as possible. With boards of the same width they can be broken every course, but when the boards are of unequal width there will be a straight joint through three or four boards. The nails of a square-edged floor are driven through the face of the board and sunk with a nail-set, to be puttied or not, according to whether the floor is finished or left bare, and a line should be drawn where nails are to be driven, over the center of the joist below.

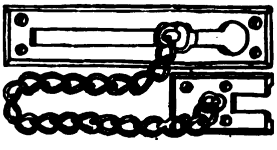


Fig. 90. Chain Bolt.

Floor Paper. Between the upper and under floors it is well to lay a deafening of paper. This may be an asbestos felt, which is valuable on account of its fire resisting qualities, or a common floor paper may be used, and should be put down in two thicknesses.

Matching. Where finished hardwood floors are used, it will be necessary to have the floor boards matched so that the nails may be concealed. Blind nailing, this is called, and by this method the board will be nailed only on one edge, and the matching depended upon to hold down the other edge of the board. For this reason the floor should be laid of narrow strips each with a tongue and groove, the grooved edge being forced over the tongue of the preceding strip and the tongue in turn nailed diagonally. (Fig. 92.) The under floors, where a nice, handsome upper floor is desired, should be in narrow widths not over four inches wide, for each board in shrinking will compress as many strips of the upper floor as may be upon it, together, leaving a wide crack over the crack in under floor. This defect may be overcome by laying the under floor diagonally or at right angles to the upper floor.

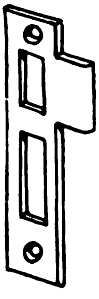


Fig. 91. Striker.

Stock. Of flooring stock in general, quartered oak makes the best floor for appearance and wearing quality, but birch and maple are used to a great extent, and rift hard pine will make a good floor for ordinary use. Quartered oak is sawn from the trees as nearly as is possible on radial lines (Fig. 93), and shows an even, straight grain with irregular streaks, upon a ground of fine parallel lines. In rift hard pine the parallel grain is more pronounced and of a coarse growth. All flooring must be kiln-dried and laid hot from the kiln, or as soon as possible after delivery. To obtain a perfectly even surface the floor must be "traversed", that is, planed across the grain so as to bring the floor to a perfectly level surface. A thin floor which is only $\frac{5}{16}$-inch thick is used to good advantage over an under floor which is in good condition. This floor is skillfully handled by a professional floor-layer, and is often laid to a more or less fancy pattern. Being too thin to match, these floors are nailed

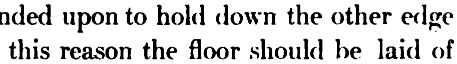


Fig. 92. Blind-Nailing.

through and the nail holes are so cleverly puttied up as to be almost invisible. It is a good plan to keep artificial heat in the building while the floors and finish are being put up, which should be maintained until occupancy. This is especially necessary in the case of parquetry floors.

Miscellaneous. A number of different points connected with the finishing of the house will now arise, and the superintendent will do well to inspect the work constantly to see that every visible detail is completed as it should be. Thresholds should be carefully fitted, cornices, chair-rails, and picture-mouldings run level and true. Sashes must be tried to be sure that they are accurately balanced and hung. Every sash-fast, lock and knob must be examined and all drawers, slides and other movable fixtures tested and left in good working order.

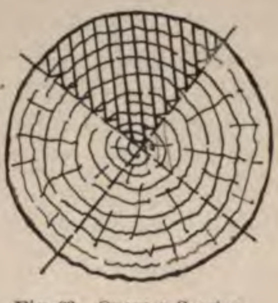


Fig. 93. Quarter Sawing.

PAINTING.

Exterior Painting. The outside finish of the house should have received as soon as put up the first or priming coat of paint, this is usually done more or less by piecemeal as the different parts of the house are completed, and will require attention mainly to see that the materials are pure and that the surfaces are well covered. This first coat should contain a large proportion of white lead, which will adhere to the new wood far better than any other substance and will retain the second coat well. Pure linseed oil should be used, but unless care is taken this is likely to be adulterated with fish oil which dries slowly and never hardens like pure oil. The only way to detect the presence of fish oil is by its fishy smell and this is sometimes hard to observe. Linseed oil is also adulterated with oils of resin and pine, and these are very hard to detect, except by long experience.

Puttying. After the application of the priming coat, all the nail holes and cracks must be stopped with putty, the nails having previously been "set" by the carpenter when the finish was put up.

The final painting of the exterior will naturally begin with the roof and be carried downward so that portions already done will not be spattered by subsequent operations. If the roof shingles are to be painted or stained they should have been dipped in the paint or stain for a distance of at least two-thirds from the butt, before being laid. This is a tedious process but is well worth the extra trouble and expense. Another method is to paint each course of shingles as it is laid, but this is fully as objectionable a process as dipping. In either case the coloring of the roof shingles will have become hard by the time the walls are painted so that there will be no staining of the work below.

Colors. In the choice of a color for the exterior a few general suggestions may properly be made here. In the first place, it is of prime importance that the house should harmonize in its exterior colors with the surroundings. If the house is to be surrounded by plenty of growth, such as trees or shrubs so that the tints of vegetation will predominate, the tendency may well be toward shades of green, yellow, or brown, which will harmonize with the changing effects of the growth. On the other hand, if the situation is one where rocks and ledges will necessarily lend a grayish tone to the surroundings, the house may well be painted in shades of gray.

Colonial Colors. For a colonial design, such as we have adopted, the old-fashioned idea of painting the trimmings white and the body color of yellow ochre or gray, may be properly considered. Of these the gray body will prove more lasting as the yellow ochre often becomes subject to mildew when exposed to continued dampness. In general, light colors last better than dark colors and do not "draw" the joints of the finish.

Exterior Stains. For shingled houses, stains of various colors and ingredients are often used. These are not so durable as paint, but have the merit of preserving the texture of the shingles, which is completely lost by the application of paint. Creosote stains, pine tar stains and oil stains may be obtained. Of these the creosote stain acts as a preservative for the wood, especially if the shingles are dipped before laying. In the lasting qualities of these stains there is little choice, creosote and tar both disappear in time through the action of sun and rain, while the tendency of oil stain is to blacken or mildew.

In some situations a preference may be had for an unpainted exterior, the desired effect being obtained by the action of the elements. In this case shingles should be used for the covering, as clapboards or siding are liable to split if not protected with paint. In any case the exterior finish and mouldings should be painted or they will warp and twist out of place.

Priming. Before priming the painted finish, all knots, sap and strong discolorations must be "killed" with a strong coat of shellac to prevent any staining, which will occur unless this is done. The painter must be required to examine the finish and report any defects, which must be remedied by the carpenter, and all finish should be gone over with sand-paper before each coat. As to color of the priming coat, white or almost any very light color will do, and it is often well to include in the contract simply this and another finishing coat, as the work will be better done with less opportunity to cover up poor work and less liability of blistering than if three or four coats are applied at once, and a third coat may be applied after two or three seasons to better advantage. An exception should be made in regard to sashes, which should have three or four coats at once. While it is essential that the first coat should be of lead and oil, for the subsequent finish it is not so important. Some of the patent mixed or "chemical" paints are convenient and will last well, especially away from the sea-coasts. Paint should be applied by long strokes parallel to the grain of the wood, and no portion of work should be started in the morning which cannot be finished, or carried to some definite stopping place before night, as the joining of work done at different times will always show a bad place. The back of lattice should be painted and all conductors and metal finish and roofs. Canvas roofs are best treated by dampening and giving a good coat of oil with yellow ochre, then two or three coats of lead and oil paint.

In regard to exterior painting, the use of turpentine is to be avoided, as turpentine does not resist the action of water and so will not preserve work which is exposed to the weather. As oil possesses a natural tendency to discolor white paint, it is customary to mix turpentine with the oil when an absolute white is desired, but in dark colors this is not necessary, and boiled oil only should be used unless a dryer is needed.

Inside Painting. While the same principles apply to the inside painting as to the outside, more care should be exercised in the application. Puttying must be done with the greatest of care, and a greater skill in the application will be needed. If a painted finish is desired greater care must be taken in protecting from knots and pitch by the use of shellac, even to the extent of shellacing the whole finish if it is necessary. For inside painting zinc is used to a large extent, instead of lead, and is often preferred as it has no tendency to turn yellow in rooms which are not well lighted, as lead will sometimes do. Tastes vary as to the kind of surface desirable for painted finish. If a dull finish is desired it may be obtained by mixing the last coat of paint with clear spirits of turpentine instead of oil. Oil gives a somewhat glossy finish and if a high gloss is desired varnish may be mixed with the last coat. The so-called enamel finish is very popular and is obtained by the application of five or six coats of paint, each coat rubbed down with pumice and oil, the last coat being of a prepared enamel.

Inside Staining. Staining in various tints is a popular way of finishing many interiors. This is done sometimes to change the natural color of oak or other hard woods, and more often to give a desired tone to softer woods such as whitewood or cypress.

Stains are in general of three kinds, water stains, oil stains and spirit stains. The richest color effects are produced by water stains, for the reason that their work is performed by absorption and there is thus less tendency to obscure the grain of the wood. Oil stains are superior to water stains in the matter of preserving the wood and, by reason of not freezing, their use in cold weather is an advantage, but the result is a loss in clearness of grain and color effects. For renewal of old work oil stains should be used, as the previous finishing will prevent proper absorption of the water stain. Spirit stains tend to strike into the wood by evaporation, requiring about twice as much to cover the same area as water or oil stains, and they are not so extensively used.

Varnish and Shellac. Where a natural finish is desired the treatment will vary from the simple application of a coat or two of oil, which makes the cheapest and poorest finish, to five or six coats of shellac, rubbed down, which gives the most costly and best of all finishes. The actual treatment will vary with the wood and finish desired. We find that our painting specification has been very carefully drawn, giving the hardwood finish after cleaning, first a coat of oil or paste filler, this is cleaned off and four coats of shellac applied, each coat when dry being rubbed down with fine sand-paper except the last. This coat will be rubbed to an egg-shell gloss with pumice stone in oil. The hard pine finish of the service portions of the house will be given a good coat of oil to bring out the grain of the wood. This will be smoothed by sandpapering and then given a good coat of spar varnish rubbed down, and a final coat of the same, this last coat flowed on and left shining.

Preparation. For a first-class finish certain conditions must be observed, first in importance being to have a smooth and clean surface upon which to work. This can best be assured by a careful sandpapering of all finish until perfectly smooth, when all traces of dust should be removed. If stain is to be used it may then be applied and, after drying, sand-paper lightly to bring up the high lights and smooth the grain which will be raised somewhat by the application of the stain. A second coat of very dilute stain lightly applied with a cloth will often improve the grain. This may be followed by a very light coat of shellac to protect the solid parts of the wood from absorbing too much of the filler, thus improving the contrasts and preventing a muddy appearance that is sometimes seen.

Filling and Finishing. The wood is now ready to receive the filler which should be used on open grained woods such as oak, ash, chestnut, mahogany, etc. Either a paste filler or an oil filler may be used, preference generally being for the former. This is applied in a thick coat, the surplus being wiped off with a cloth, and the whole sand-papered lightly.

After filling, another coat of shellac may be put on and sand-papered, and this may be followed by two or three coats of varnish or shellac according to the finish desired.

Shellac and Varnish. The choice of shellac or varnish for finishing will depend upon the use, condition, or situation of the work to be finished.

In conditions of dampness or where the finish will be subjected to the action of water to any extent, it will be better to use varnish, as the effect of water is to turn shellac white. Varnish, when thoroughly dry, is not affected by ordinary applications of water. For this reason, if there is any suspicion that the finish is not thoroughly dry, it will be safer to use varnish in direct contact with the wood as the final seasoning of some of the more "sappy" woods, such as cypress or hard pine, will sometimes produce enough moisture to whiten the shellac, even under subsequent coats of varnish.

In kitchens, pantries, bathrooms and in general the whole service portion of a house, it will be better to use varnish, as the application of water will be more general in these parts than in the main rooms.

Rubbing Down. The rubbing down of shellac or varnish is a protection against whitening, and for this reason, besides the gain in appearance, every coat, especially in finishing in shellac, should be rubbed down. This rubbing down may be done with fine sand-paper, or hair-cloth or curled hair, and the last coat may be treated in various ways according to the finish desired. To obtain an egg-shell gloss for the final surface the last coat should be rubbed with pulverized pumice stone and raw linseed oil. For a dull finish water may be used instead of oil with the pumice, and for a highly polished surface, a rubbing with pumice and water may be followed by polishing with "rotten stone" and water. Work that is to be polished should never have less than three varnish coats, but an egg-shell gloss may be obtained with two coats.

Floor Finish. To obtain permanent wearing qualities in the finishing of floors is a troublesome matter. The elastic varnish which we have used for the standing finish requires a different treatment when subjected to the wear and tear of floors. Referring to the specifications, we find that the floors are to be stained as approved, and the oak, which is an open grained wood, is to receive a coat of oil filler, this brings out the grain of the wood and it is then ready to receive three or four coats of shellac each sand-papered as before and the last coat rubbed with pumice stone in oil or water to a dull finish.

For floors of maple, birch or any close grained wood the oil filler would be of no use and its place would be taken by extra coats of shellac. For hard pine floors of the kitchen, back halls and bathroom, which are subjected to a great deal of use and more or less water, satisfactory finish may be obtained by giving simply two coats of oil with turpentine dryer added to prevent the dust from sticking as it would to clear oil. A finish less expensive than the shellaced finish for hardwood floors is obtained by use of wax polish which is applied to the wood after filling or better, over one or two coats of shellac. This is a paste which enters the pores of the wood, dries in a few hours, and can then be polished with cloths or by dragging weighted brushes, which are sold for the purpose, to and fro over the floor. By keeping a brush and the wax at hand, any worn spots on the floor can be easily renewed and the whole kept looking well indefinitely.

A first-class job of finishing should never be hurried, but each coat should be thoroughly dry. Varnish should be applied at a temperature of about 70° F. and this temperature should be maintained until the varnish is thoroughly dry. Clean brushes should be used at all times, and a rising of dust in a room should be wet down and checked until the varnished work is completely dry.

Miscellaneous. Beside the standing finish and floors, miscellaneous parts must receive the painter's attention. Pulley stiles of windows must be oiled, sashes drawn, exposed brass piping shellaced, and thresholds oiled or varnished. All of these minor details will need the attention of the superintendent or they will be overlooked. Other than this, the supervision of the painting work will be mainly to see that the best of materials are used. To this end it will be necessary to insist that all paints shall be mixed at the building, and that all materials are of the specified kind and are brought to the building in the original cases or kegs.

Tinting. It will generally be found necessary that the ceilings and walls which are not covered with paper or hangings, shall be tinted or frescoed. This is a matter which needs to be done by careful workmen who understand the preparation and application of the colors. Much depends upon the first or sizing coat and this should always be applied before tinting or fresco of any kind is done.

Glazing. It is usually the custom to send the sashes to the building all glazed, so that the superintendent needs only to see that the glass is of the specified quality and whole. Common window glass is called sheet or cylinder glass, and is rated as double or single thick, and as first, second or third quality. Formerly all glass was imported from France or Germany, but American glass has come to be used in general in the greater part of the United States.

In the Eastern States window glass is still imported and it is customary in the East to specify German glass for the best work. For lights up to twenty-four inches in width, single-thick glass may be used, this is about one-sixteenth of an inch in thickness, while double-thick glass is about one-eighth inch.

The best quality of common American glass is known as AA, the second as A, and the third as B. Sheet glass is made by blowing the molten glass in a cylinder about fifteen inches in diameter. This is trimmed and cut longitudinally and heated until it can be opened out flat. Sheet glass always retains a vestige of its curvature.

Between first and second quality glass it will be difficult to distinguish except by practice, but defects or unevenness may be seen at once, and plate glass is always readily distinguished, by reason of its polish and its absolute freedom from imperfections of any kind.

Plate Glass. For lights more than five feet square plate glass must be used. This may be obtained in three grades, French plate and two grades of American plate. French plate, and the first or silvering quality of American plate, are used almost entirely for mirrors, while the second quality of American plate is used for glazing.

American glazing plate is made in one quality only, and is usually one-quarter inch thick for ordinary sizes, but is necessarily thicker for large lights, and may be obtained in sheets as large as twelve by seventeen feet. Plate glass is absolutely straight, being cast on a perfectly flat cast iron table and rolled to the required thickness. The rough plate thus formed is carefully examined for flaws which are cut out, leaving as large a sheet as possible which is polished. French plate may be distinguished from American plate by the color, when looked at endways. The French glass shows perfectly clear and white, while the American glass has a bluish color.

Crystal Plate. A kind of plate glass called crystal plate is made, about three-sixteenths of an inch in thickness. This is used for railway cars and in places where thin sashes must be used or a saving in weight is desirable.

Final Inspection. With the departure of the painter the house is usually complete, and ready for the architect's final inspection and acceptance. This inspection should be careful and thorough from top to bottom, and no certificate of acceptance should be issued, until the architect is satisfied that everything has been done which is actually called for or reasonably implied by the plans and specifications.

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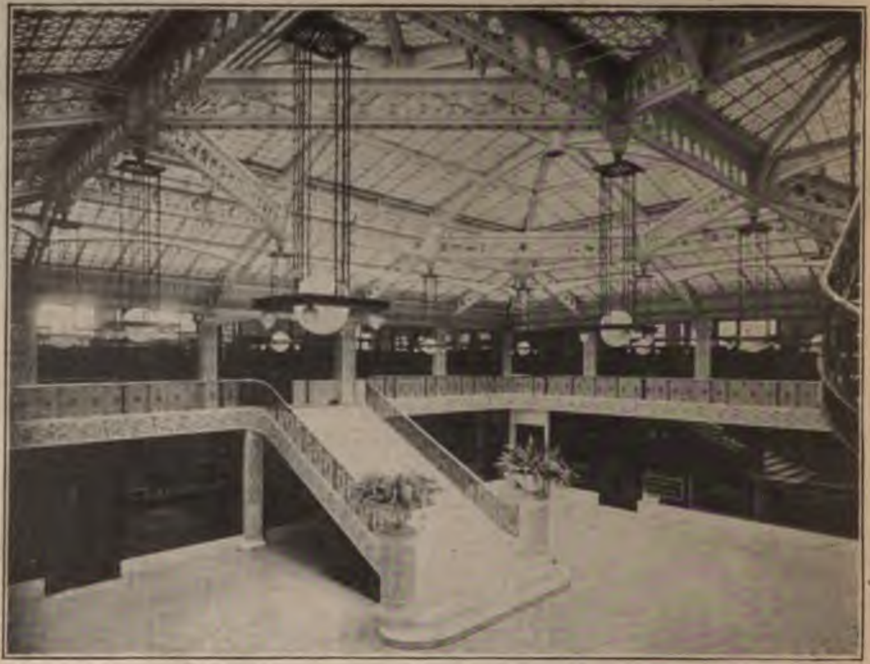
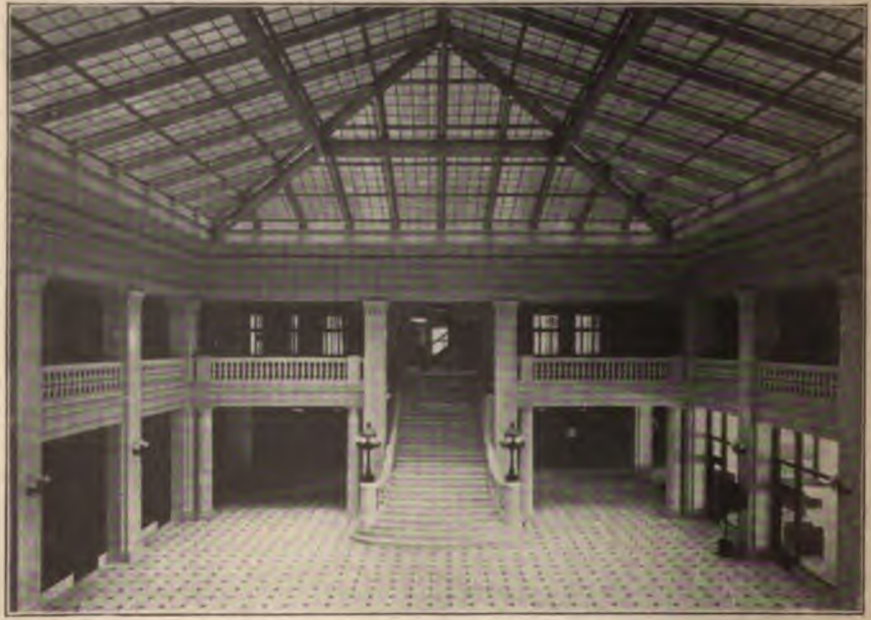


ROTUNDA IN THE ROOKERY BUILDING, CHICAGO, ILL.
Frank Lloyd Wright, Architect of the Remodeled Staircase and Light-Fixtures.
Statuary Marble, Carved with Decorative Scroll-Work, the Latter Inlaid with Gold Leaf.



ROTUNDA IN THE RAILWAY EXCHANGE BUILDING, CHICAGO, ILL.
D. H. Burnham & Co., Architects.
Note the Way in which the Doric Order has been Used in the Decorative Scheme.

BUILDING SUPERINTENDENCE.

PART II.

CITY BUILDINGS.

The requirements of city buildings, which are for the main part similar to the practices which we have already considered, are, nevertheless, in many essentials, distinct. In the first place, the circumstances of situation, soil and surroundings differ from suburban or rural conditions. Instead of being able to establish our building to meet our individual tastes, we shall find that the sidewalk and yard levels are already established, and the level of the cellars or basements will be found to be restricted in some localities. The lines of our building will also be determined, in a great measure, by established lines and restrictions so that much more of preliminary work will be needed to make the most of the existing conditions with which we find ourselves confronted.

Party Walls. Of great importance in laying out our building will be the existing agreements in regard to party walls. In most cases it will be found that there has been signed an agreement relating to the construction and use of party walls. The usual arrangement is that the party who first builds, shall build and pay for the wall, which is erected one-half on each side of the party line, and that the adjoining owner shall have the right to use and acquire the half of wall which stands upon his side of the line, by paying to the party who has already built, the cost of one-half of the wall as already erected.

As buildings of different heights require walls of varying thickness, it is usual to agree that no wall shall be primarily erected which extends more than six inches beyond the party line, so that if one owner desires to erect a building which will require a greater thickness than one foot for the party wall, he must erect all except six inches of the thickness of the wall upon his own land. While a party wall agreement will probably be a matter of record, which can be looked up in the proper place, much time may often be saved by looking for some information upon the spot.

If the land on either side of our lot be already occupied by a building, the conditions of the wall finish will be likely to afford data upon which we can work. If the finished brick or stonework covers apparently only one-half of the wall, leaving a surface of rough brick set back from the face or "ashlar line," Fig. 94, it will indicate that the wall is a party wall, as it is the usual practice for each owner to stop his front at the party line. If, on the other hand, we find the finished work covering the wall completely, Fig. 95, we may assume that the wall in question is not a party wall, but a wall built wholly upon the land of the adjoining owner. This evidence will be confirmed if, upon measuring the distance between the two lines in question, we find it to agree with the figures upon the surveyor's plan with which we must be provided before laying out our plans. The matter of party wall rights is, however, too important to be settled to a sufficient degree, by mere observation, to permit of building operations, and so we shall need to apply to our client for a copy of any agreements or restrictions, and proceed to plan and construct the new buildings in accordance with these.

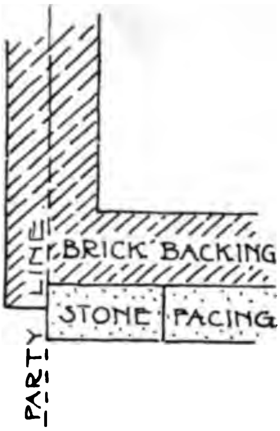


Fig. 94. Finish at Party Wall.

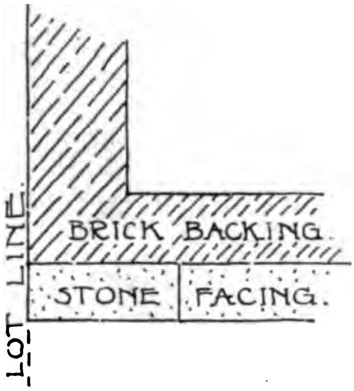


Fig. 95. Finish of Wall not a Party Wall.

Soil. If the nature of the soil upon which we are to build is not known, we must have borings made to show the composition of the soil at different levels. If two borings on opposite sides show about the same character, it will be sufficient evidence, but if these vary, then borings should be made all around. Rock, clay or gravel

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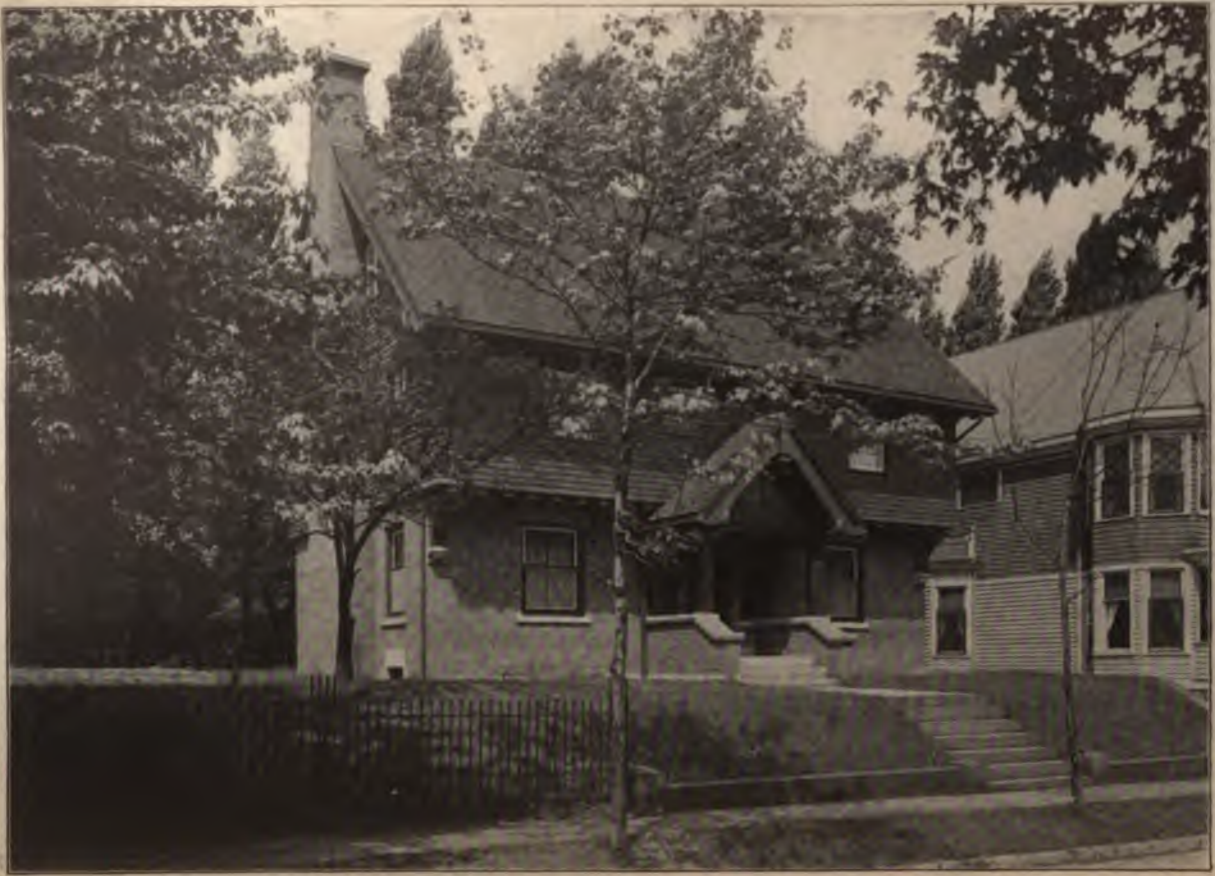
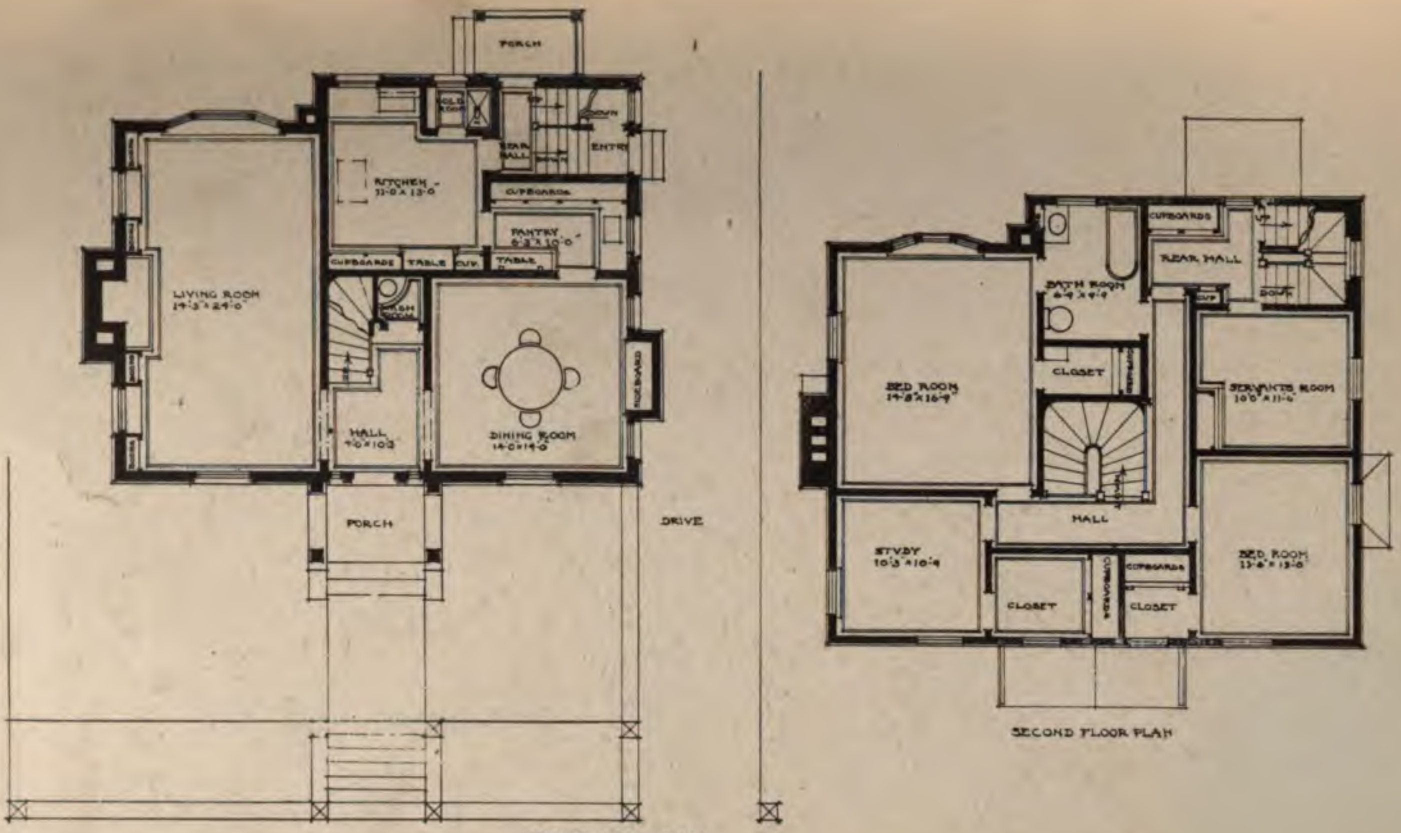


RESIDENCE OF MR. E. S. MEYER, CLEVELAND, OHIO

Watterson & Schneider, Architects, Cleveland, Ohio.

Materials: First Story of Brick; Second Story and Roofs of Shingles. Built in 1904. Cost, $7,000. For Plans, See Opposite Page.



SECOND FLOOR PLAN

-FIRST-FLOOR-PLAN-

FIRST AND SECOND STORY PLANS OF RESIDENCE OF MR. E. S. MEYER, CLEVELAND, OHIO

Watterson & Schneider, Architects, Cleveland, Ohio.

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bottom will require only that our foundations shall be made wide enough to distribute the weight of the building, and its contents, over an area sufficient to sustain it. The bearing power of rock will vary from ten to thirty tons per square foot, dry clay from four to six tons, gravel from eight to ten tons. If, however, the soil consists of mud or filled land, such as will be found on the borders of lake or ocean, it will be necessary to drive piles, upon which the footings are supported.

Pile Foundations. Piles are made of wood, cast iron, concrete, or steel, but for ordinary building they are usually made from the trunks of trees, and should be straight and sound, and at least eight inches in diameter for heavy buildings. Spruce, hemlock, Georgia pine, and oak are the principal kinds of wood in use for piles. The usual method of driving piles is by repeated blows given by a block of iron called the hammer, which works up and down between the uprights of a machine called a pile-driver. This hammer weighs from 1,200 to 2,500 pounds, and the fall varies from five to fifteen feet. Piles should be driven plumb, and any pile which has been driven for twenty feet or more, and refuses to sink more than half an inch under five blows of a 1,200 pound-hammer. falling fifteen feet, may be considered as at its depth. Several formulæ have been proposed for figuring the safe load upon piles, of which one of the latest, known as the Engineering News formula, is:

$$\text{Safe load in pounds} = \frac{2\,WH}{S + 1}$$

in which W = weight of hammer in pounds, H = its fall in feet, and S = the average set under the last blows in inches.

Piles should be spaced not less than two feet, nor more than three feet, on centers, and they must be cut off below low-water mark. The level at which piles are to be cut off will be given by the building laws of most large cities, and is established at a level which will insure of the pile being at all times under water. Under these conditions the piling will be subject to no decay, but alternate conditions of moisture and dryness will soon result in the rotting of the piles.

The superintendence of piling will consist first in an examination of the piles as they are delivered, to see that they are of the requisite length and diameter, sound and straight. The lines of the building must be carefully established, and small stakes driven to fix the position of every pile. This should be verified by the superintendent according to the piling plan furnished. When the actual driving of the piles begins there should be kept a complete record giving the length of pile, the number of blows, and the distance which the pile has sunk at each of the last (ten) blows. From this data the bearing capacity of the pile may be computed by the foregoing rule. Another formula is known as Saunder's rule and is as follows:

$$\frac{F\,H}{8\,S} = W,$$

in which F = fall of hammer in inches, S = sinking of pile at last blow, in inches, H = weight of hammer in pounds, W = safe load for pile in pounds.

Besides this record, the pile should be carefully watched while being driven, to see that it does not get out of line, that the head does not "broom" or split excessively. If there is danger of this, the head of the pile should be bound with a wrought-iron strap or a cast-iron cap. When the piles have been driven, trenches wide enough to accommodate the stone levelers must be excavated and kept free from water to a depth sufficient to allow of sawing off the piles at the required level. This is usually done by means of a cross-cut saw operated by two men, and the tops must be cut off at a level with each other. Piles exposed to tide-water are usually driven with the bark on.

Footing Stones and Concrete. Whether the bearing be piles or the natural earth, the bottom of the foundation will usually consist of large stones or of concrete. If three rows of piles are used they may be covered as shown in Fig. 96. Two rows of piles are generally capped by a series of levelers laid across the trench as in Fig. 97. A footing on earth will be laid in a like manner, and of a width made necessary by the load to be borne and the nature of the soil. The purposes of these wide footings are to spread the weight over a large area and also to add stability to the wall, and they may be of stone, brick, or concrete. For nearly all buildings on solid ground, concrete footings are probably the

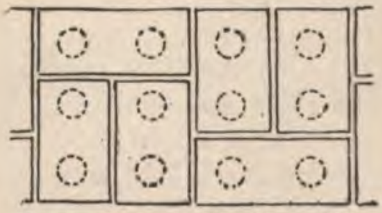

Fig. 96. Capping of three Rows of Piles.

best, and in many cases concrete capping for piles may be used to advantage.

Trenches for the footing may be dug below the regular excavation and of the exact width required, and into this the concrete may be tamped (Fig. 98). A good proportion is one part of cement, two parts of sand, and four parts of stone, for natural cement. The thickness of the footing should be one-quarter of its width (provided this does not figure less than twelve inches) put in by layers about six inches each. If this concrete is much wider than the wall over it, a stone leveler may be placed on the top, as shown in Fig. 98 A.

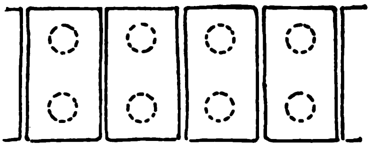

Fig. 97. Capping of two Rows of Piles.

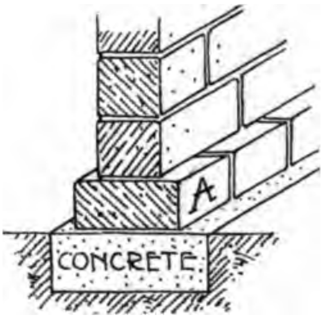

Fig. 98. Concrete Leveler.

If preferred, stone footings of a similar character may be used, as in Fig. 99, and for light buildings where stone is hard to obtain, brick footings may be used. If this is done, the offsets should never be more than one-quarter of a brick, and the outside work should be all headers, with a double course at the bottom. (Fig. 100.) This course should be laid in a bed of mortar spread on the bottom of the trench, of hard burnt bricks, thoroughly wet if the weather is dry. Too much care can never be taken to insure a good foundation. If important footings are made of concrete, an inspector should be on the work during working hours, to see that the concrete is mixed in proper portions, and put in to the full thickness shown, and tamped and leveled every six inches. The trenches must be kept free from water until the cement has set, or it will become utterly worthless, by reason of the water separating the cement from the sand. If the

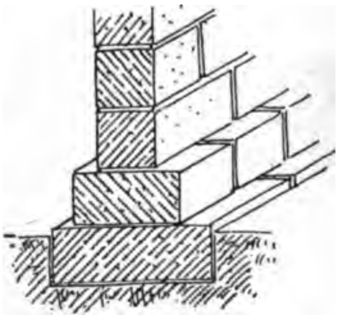

Fig. 99. Stone Footing.

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footing is of stone, the presence of water, if only a few inches deep, will do no harm, but the footing then must be bedded in firm sand or gravel instead of cement.

Foundation Walls. The foundation walls of a city building above the footing course, are usually built of stone. Concrete is used to some extent, and brick will be used for the party wall where there is to be a cellar both sides. For heavy walls of buildings, three or more stories in height, it will be necessary to use block stone. These are stones roughly fashioned to dimension and generally laying from eighteen inches to two feet in height and the full width of the wall. (Fig. 101.) Being brought nearly even and square, not much mortar will be used, and this should be of clear cement and sand below the grade line.

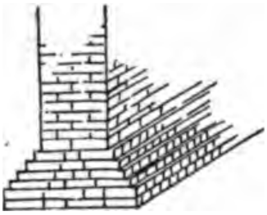

Fig. 100. Brick Footing.

Rubble Walls. For a foundation of a lighter character, rubble stone may be used. This consists of stone split from a ledge with no preparation other than breaking up with a stone hammer, and squaring one edge and face. As these stones are irregular in shape and thickness, considerable mortar will have to be used and the character of the mortar and the filling of voids will need especial attention. An important element in the strength of a rubble wall, is the bonding or the lapping of stones over each other. The stones should be laid in irregular courses leveled off to a horizontal joint about every two feet, and a bond stone should be put in at intervals of four or five feet. Most city laws require a certain proportion of bond stones, and, if nothing is said, a through bond stone should be inserted into every five or six square feet. Care must be taken that the stones are bonded also in the direction of the length of the wall, so that no vertical joints may appear running through three or four courses. Outside of the bonding,

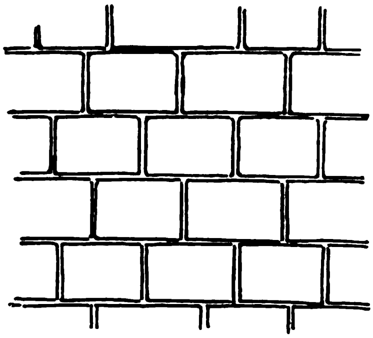

Fig. 101. Block Stone Wall.

the manner of laying the stones must have our attention. All the stones must be laid as nearly as possible on their natural bed, that is, with their splitting surface horizontal. Angles and corners must be carefully laid with large stones bonding across each way, as in Fig. 102.

With a heavy foundation wall of block stones, where each stone is of the full thickness of the wall, the main care will be to obtain a good bond, with level and plumb joints. Openings for pipes should be left when the wall is being built, as it may be difficult to break an opening after the walls are carried up.

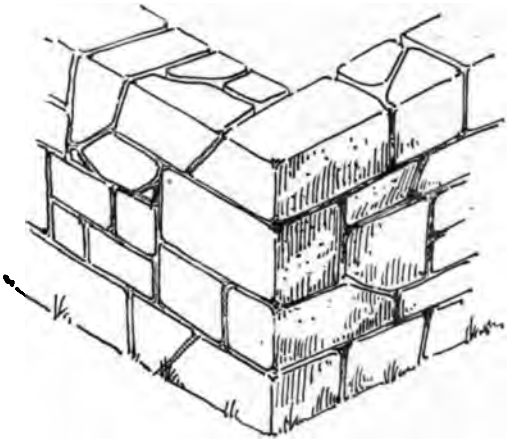
Fig. 102. Bonding of Corner.

Derrick Stones. All of the stones which are suitable for the heavy walls which we have described should be large, and will require the use of derricks in handling. If the building is to be one of great size or height, a system of three or four large derricks will probably have been started, swinging from some central scaffold, and guyed to this and to each other. For a building of but three or four stories however, the builder would probably use a series of smaller derricks supported each by its own guy ropes. The superintendent should make sure that the ropes are strong and not frayed out, that the mast and boom are neither cracked nor sprung, and that the running gear is strong and shipshape. The securing of the guy ropes is a very important matter, and should be noted by the superintendent. Although it belongs to the contractor to do this, a careful inspection by the architect will doubly insure the safety of all concerned. In suburban or out-of-town work the guys will usually be secured to a convenient tree, and this should be a young or evidently sound tree, or if posts have to be put down, as will be necessary in the city, they should be set deep in the ground with the earth well tamped in again. The guys must be at all times drawn taut, as a loose guy will be given a sudden and dangerous strain if a heavy stone is swung around so as to bring its weight upon it.

The derrick will allow of heavy stones being carefully set, and this will be especially noted in the handling of the capstones for the piles. These will have been selected for an even bed and can be shifted until they rest immovable on the piles. In bedding, the heavy stones may be held suspended over the place where they are to lie while an even bed is being prepared, and, if necessary, the stone may be lowered and then raised again before the final setting, so that the impression will show where the bed will need fitting.

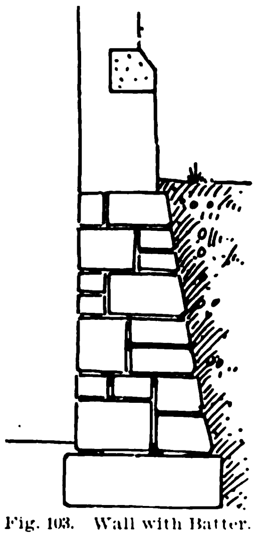
Fig. 103. Wall with Batter.

Thickness of Walls. The thickness of foundation walls in all large cities is controlled by law, and in general will require that walls to a depth of ten or twelve feet below the ground shall be four inches thicker than the wall above, for brick, and eight inches for stone, with an increase of four inches for every ten feet below this. In clay, which is more seriously affected by frost than gravel, it is a good plan to build foundations with a batter on the outside of six to twelve inches, as in Fig. 103, so that any movement of the earth will readily free itself from the wall, which should be made smooth on the outside with cement.

Areas and Vaults. Areas are often required, to give light or access to basements, and these will need a retaining wall to keep back the earth. Stone should be used for areas of any size, and, in excavating, the bank should be disturbed as little as possible and refilled carefully. If the area is not more than six or seven feet deep, a good wall of a uniform thickness of twenty inches will be sufficient but, if deeper, the wall should be made wider at the bottom and battered. If the wall is more than ten feet long, cross walls or arches should be built to connect with the main building. The bottom of the area should be carried at least six inches below the sill of window or door, and covered with stone flagging or brick laid in cement, with a small brick cesspool and cover, connected with the main drain.

The space under the sidewalks and entrance steps or porches is often utilized for coal or general storage purposes. This requires a wall at the street line which shall be heavy enough to sustain the pressure of the street and the weight of the sidewalk. If it is possible to divide this space so that the partition walls can be run back to the main building about every ten feet, the construction can be simplified, but if an open space is required, a very heavy wall must be built at the street line, and steel beams laid from this wall to the building which will buttress the top of the street wall and support the weight of the sidewalk as well. Brick arches may be turned between these beams and leveled up for the sidewalk, or a concrete or flagstone sidewalk may be constructed over them. (Fig. 104.) If brick arches are turned, to be covered with an ordinary brick paving, the top of the arch should be coated with hot asphalt. Any of the modern forms of fireproof floor construction may be used for the sidewalk covering, finished with concrete or "granolithic" surface.

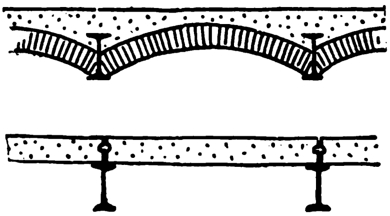

Fig. 104. Sidewalk Beams.

Dampness. As a protection against dampness, the outside of all cellar and vault walls in wet situations, should be coated with hot asphalt or Portland cement. Asphalt, applied while boiling hot in two or more coats from top to bottom, is considered the most lasting, if the ground is very damp, as Portland cement is affected by frost and is easily cracked by settlement of the walls, while asphalt, having considerable elasticity, remains sound and tight. Coal tar is sometimes used, but will gradually become brittle and crumble away.

BRICKWORK AND CUT STONE.

In the superstructure of a city building of ordinary height, say up to five or six stories, and excepting the so-called skeleton construction, we shall usually find that brickwork forms the greater part of the wall. The face is often finished with stone, either rough or cut, but the backing, and often the face as well, will usually be constructed of some form of brickwork, so that bricks of some kind or another are probably more extensively used in the construction of city buildings than any other material.

The advantages of bricks over stone are that they are practically indestructible, either from the action of fire or the elements; they are less expensive and more easily handled. Good building bricks of their respective kinds should be sound and free from flaws and stones or lumps of lime, uniform in size, and square, hard and not too absorbent. A good hard brick will ring distinctly when struck by another brick or by a trowel, and it should not absorb more than ten per cent of its weight of water. In selecting bricks from a quantity delivered, the hard and usually darker bricks should be culled for use on the outside of the walls, while the lighter bricks should be used for backing and the inside courses.

Thickness of Walls. No practical rule can be laid down for the thickness of brick walls, as their crushing strength, which is usually the only direct strain applied, is generally, except in the case of small piers, a minor consideration. In all large cities the least thickness of walls will be fixed by law, walls of mercantile buildings being heavier than those used for living purposes; and in no case is it advisable that party walls should be less than twelve inches thick. Exterior walls in general, for a building of five stories, should not be less than twenty inches in the lower story and twelve inches in the upper story. These dimensions applying to stories of ordinary height, and spans of not more than twenty-five feet, nor more than twenty-five feet of length without a pier. Walls which contain thirty-three per cent of openings should also be made thicker.

Brick Laying. To perform the operation of erecting a brick building it is necessary to lay the carefully chosen bricks upon each other, with a bed of some kind of mortar between. Ordinary brickwork is laid in common white lime mortar, but for greater strength and durability there is often added a proportion of cement, and for brickwork below ground, cement mortar only should be used. The thickness of the joints will vary from three-sixteenths of an inch to three-eighths of an inch, according to whether the joint is to be concealed or made a feature of the work.

The laying of the bricks should be carefully watched, as there is a tendency on the part of many masons to slight this work. "Bricks should not be merely laid, but every one should be rubbed and pressed down in such a manner as to force the mortar into the pores of the bricks, and produce the maximum adhesion; with quick-setting cement this is still more important than with lime mortar. For the best work it is specified that the brick shall be laid with a 'shove-joint,' that is, that the brick shall first be laid so as to project over the one below, and be pressed into the mortar, and then be shoved into its final position. Bricks should be laid in full beds of mortar, filling end and side joints in one operation. This operation is simple and easy with skillful masons, if they will do it, but it requires persistence to get it accomplished. Masons have a habit of laying bricks in a bed of mortar, leaving the vertical joints to take care of themselves, throwing a little mortar over the top beds and giving a sweep with the trowel which more or less disguises the open joint below. They also have a way after mortar has been sufficiently applied to the top bed of brick, to draw the point of their trowel through it, making an open channel with only a sharp ridge of mortar on each side (and generally throwing some of it overboard), so that if the succeeding brick is taken up, it will show a clear hollow, free from mortar, through the bed. This enables them to bed the next brick with more facility, and avoid pressure upon it to obtain the requisite thickness of joint. Neglect in wetting the brick before use is the cause of many of the failures of brickwork. Bricks have a great avidity for water, and if the mortar is stiff and the bricks dry, they will absorb the water so rapidly that the mortar will not set properly, and will crumble in the fingers when dry.

"Mortar is sometimes made so thin that the brick will not absorb all the water. This practice is objectionable; it interferes with the setting of the mortar, and particularly with the adhesion of the mortar to the brick. Watery mortar also contracts excessively in drying (if it ever does dry), which causes undue settlement and, possibly, cracks or distortion. The bricks should not be wetted to the point of saturation, or they will be incapable of absorbing any of the moisture from the mortar, and the adhesion between the brick and mortar will be weak. The common method of wetting brick by throwing water from buckets or spraying with a hose over a large pile is deceptive, the water reaches a few bricks on one or more sides and escapes many. Immersion of the brick for from three to eight minutes, depending upon its quality, is the only sure method to avert the evil consequences of using dry or partially wetted brick. Strict attention must be paid to have the starting course level, for the bricks being of equal thickness throughout, the slightest irregularity or incorrectness in it will be carried into the superposed courses, and can only be rectified by using a greater or less quantity of mortar in one part or another, a course which is injurious to the work. A common but improper method of building thick brick walls is to lay up the outer stretcher courses between the header courses, and then to throw mortar into the trough thus formed, making it semi-fluid by the addition of a large dose of water, then throwing in the brickbats (sand and rubbish are often substituted for bricks), allowing them to find their own bearing; when the trough is filled, it is plastered over with stiff mortar, and the header course laid and the operation repeated. This practice may have some advantage in celerity in executing work, but none in strength or security."

A modification of this practice, where the bricks are laid dry and grouted with moderately thin mortar *in every course*, may be successfully used in weather when there is no danger of freezing, and will make solid work. This is especially so for footings and foundations of brick where it is necessary that every joint shall be filled, as the thin grouting is more to be depended upon to fill every joint than the average mason.

Joints. For inside walls which are to be plastered or otherwise concealed, the joints may be simply cut off flush with the trowel, but where the walls are exposed, the joints should be "struck." (Fig. 105.) This consists in pressing or striking back with the trowel, the upper portion of the joint while the mortar is soft, so as to form a sloping surface from the bottom to the top. "Keyed joints" are formed by running an iron jointer with round or V-shaped edge along the center of the flush joint, giving it a depression and hardening the mortar by the pressure. (Fig. 106.) Ruled joints are made by holding a straight-edge under the joint and running the jointer along, making a perfectly straight joint.

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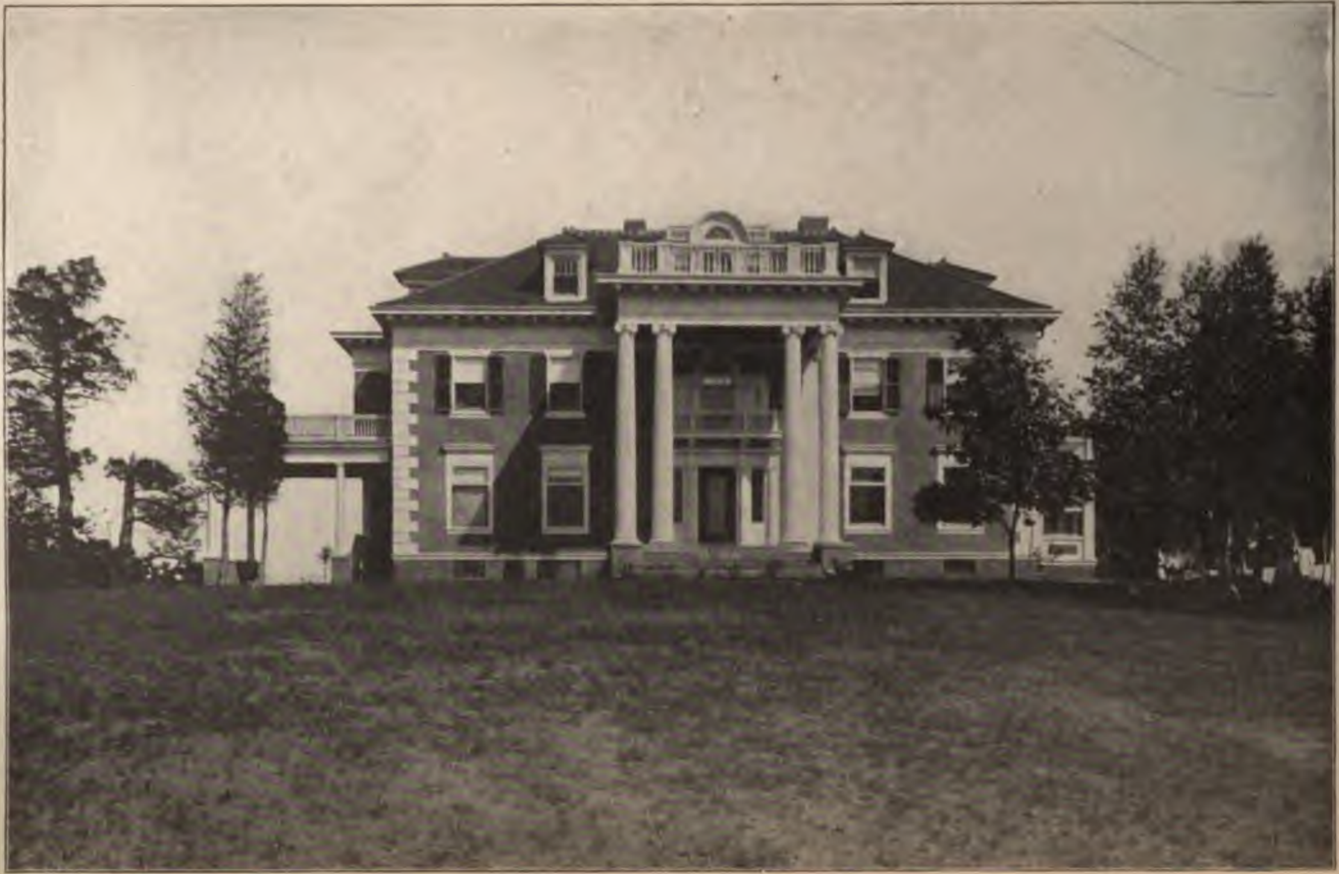
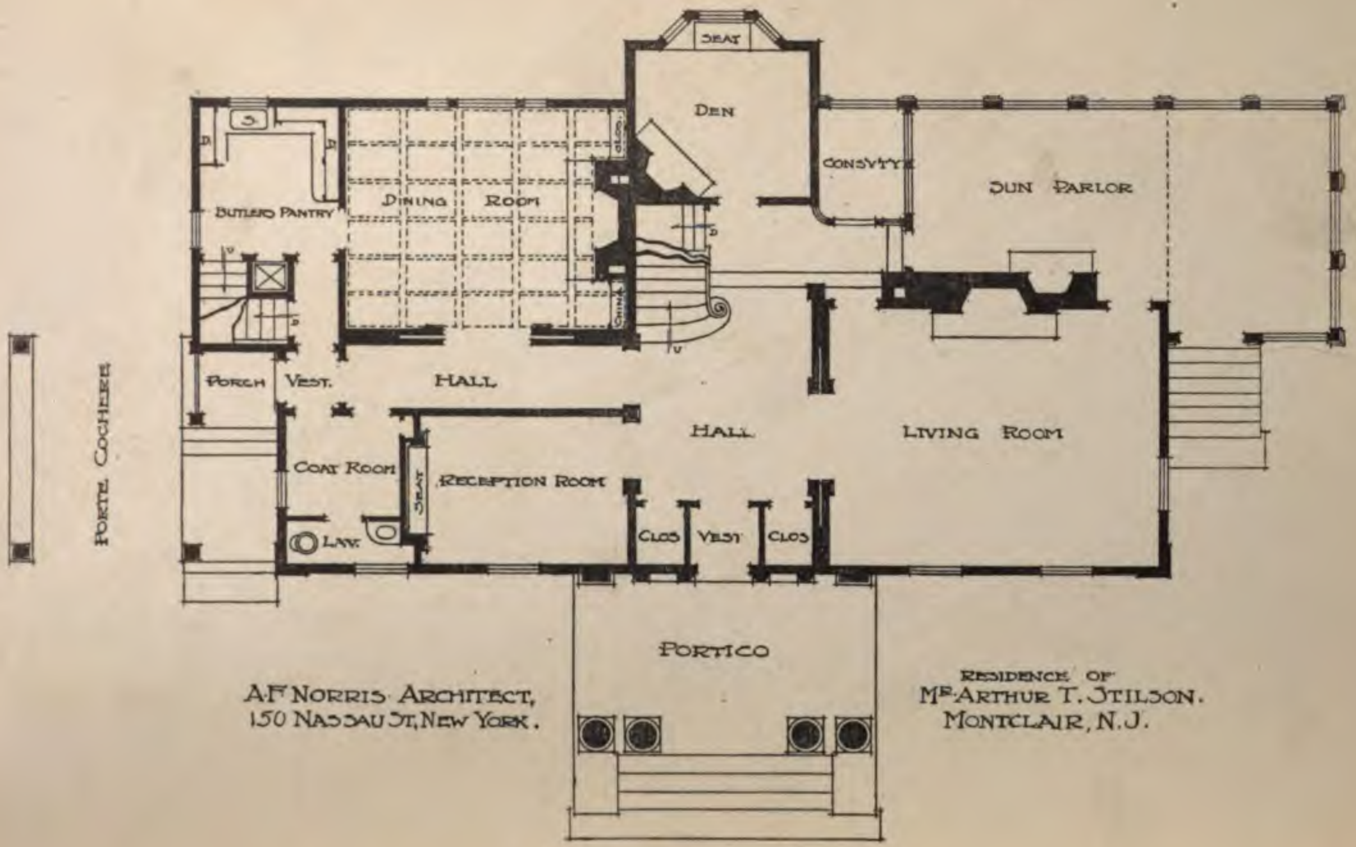


RESIDENCE OF MR. ARTHUR T. STILSON, MONTCLAIR, N. J.

A. F. Norris, Architect, New York.

A Large Ionic Order Used on the Front Porch. For First-Floor Plan, See Following Page.



· First · Floor · Plan ·

RESIDENCE OF MR. ARTHUR T. STILSON, MONTCLAIR, N. J.

A. F. Norris, Architect, New York.

For Exterior, See Preceding Page.

Bonding. The strength of a brick wall depends not only upon the bricks, the mortar, and the workmanship, but the assembling of the different members, the bond or arrangement adopted for tying together the separate parts, and also for distributing the effects of concentrated loading. The common bonding consists of laying every fifth or sixth course of bricks at right angles to the direction of the wall, as in Fig. 107. These courses are called header courses and serve to tie the wall together. Where the wall is faced with pressed brick and the regular occurrence of header courses would not look well, the face work is tied to the backing by clipping off the back corners of the face bricks, and inserting a course of diagonal headers. (Fig 108.) Galvanized steel ties of patented manufacture are extensively used in the East and are effective for this purpose. English bond is a bonding much used in England and consists of alternate courses of headers and stretchers, as in Fig. 109.

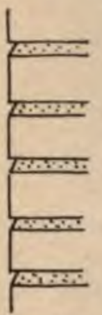


Fig. 105. Struck Joint.

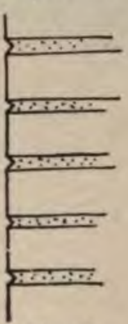


Fig. 106. V-Joint.

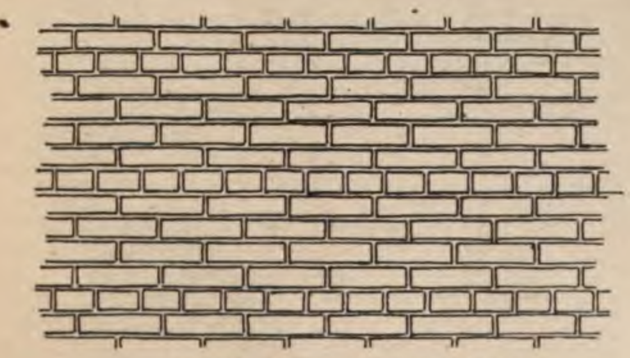


Fig. 107. Common Bonding of Brick.

Flemish bond, Fig. 110, consists of alternate headers and stretchers in each course. This bond is sometimes used effectively in facings of common brick, by using blackened headers, and it is sometimes used for every fifth course of face work instead of the diagonal headers. The bonding of angles is an important matter, and, in addition to most of the city laws require that the corners shall olts. In joining new work to old, however, direct bonding should be avoided for fear of unequal settlement, and some such method as shown in Fig. 111 should be adopted.

Hollow Walls. To overcome the tendency of a solid brick wall to transmit heat, cold, or dampness, hollow walls are often used. A given number of bricks, if built as a hollow wall, will make a more stable wall than a solid wall built from the same number; besides the gain of the air space. Nearly all building laws require the same amount of brickwork, independently of the air space, in hollow walls, as is required in solid walls, so that there is a loss of space which must be considered in city building.

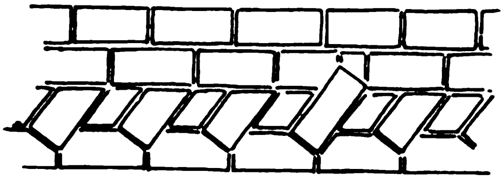


Fig. 108. Diagonal Bond. (Plan.)

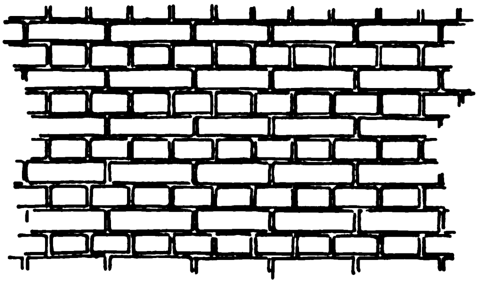


Fig. 109. English Bond.

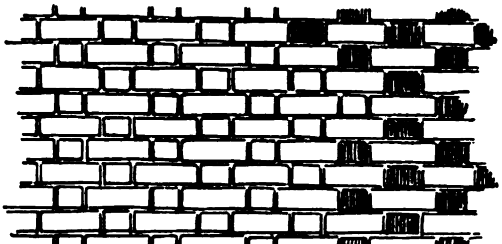


Fig. 110. Flemish Bond.

An important consideration is the bonding of the two portions of a hollow wall so that each shall help sustain the other. The usual method has been to do this by means of withes or headers of brick extending across the air space, as in Fig. 112, but these permit the moisture to pass from the outer to the inner shell, and also allow the mortar dropped from the higher portions of the wall to collect and partially fill the space; a more effective method of bonding is by means of a metal tie, either of steel wire or of iron, and these should be made with a dip in the center to allow any moisture which may come from the outer wall to drop off and not communicate with the inner wall. (Fig. 113.) These ties should be either galvanized or dipped in hot asphalt. It is a good plan to provide for a circulation of air through the space between the walls, by leaving openings in the basement and in the attic where possible. Hollow bricks are sometimes used for the inside course of exterior walls, but, while they are partially effective in excluding moisture, they do not fill the place of a hollow wall.

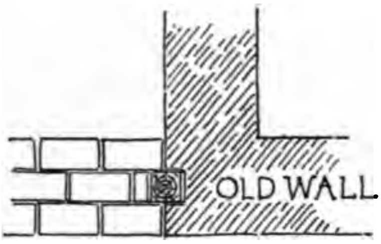


Fig. 111. Joint of New and Old Work.

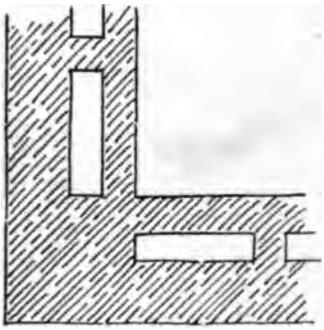


Fig. 112. Hollow Wall.

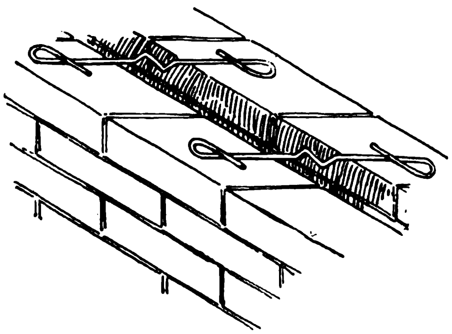


Fig. 113. Metal Wall Ties.

Common Bricks. We have made free mention of "common bricks," "face bricks," etc. Let us pause to consider just what is meant by the terms. Common bricks include all rough unpressed bricks which have had no special care taken in their manufacture. These, according to their position in the kiln, become burned to varying degrees of hardness. "Arch brick" are those which, from being near fire, become burned to a great degree of hardness and are often warped, vitreous, brittle, and weak. "Red bricks" are those which are burned with an even and moderate temperature and compose the bulk of the kiln. Salmon, or soft bricks are those which are found at the top of the kiln and are usually underburnt. They are good only for inside courses and for lining chimneys. Face bricks, in which general term are included pressed bricks, moulded bricks, etc., are made or re-pressed in a dry press machine. Face bricks are more expensive to use than common bricks and are generally used for facing exterior walls, for fireplaces, and for moulded work. "Enameled bricks" are bricks whose face is covered with a coat of enamel of selected color. The true enameled brick is a very expensive article, so that most of the bricks called by this name are glazed bricks, the difference being that the true enamel is fused into the clay and is opaque in itself, while the glaze is formed by coating the surface with a colored film and covering this with the transparent glazing. This film is apparent on chipping off the glazing, while the true enamel shows no line between the body of the brick and the surface.

Both glazed and enameled bricks are impervious to moisture and are excellent for the facing of halls, courts, or wherever a light, clean and waterproof surface is desired. In addition to these, special bricks are made for special purposes, as fire bricks for furnace linings, etc., which are open-grained or porous to admit of a rapid loss of heat, and paving bricks which are burned to vitrification to withstand the wear of travel and the action of frost.

Sizes. The sizes of bricks vary with the maker and with local customs. Common bricks in New England average about 2¼ × 3¾ × 7¼ inches; in the Western States about 2½ × 4⅛ × 8½ inches. Face bricks are more uniform in size and average about 2⅜ × 4⅛ × 8⅜ inches. Pressed bricks are also made in a thinner pattern 1½ × 4 × 12 inches. This style is known as the Roman brick.

Freezing of Brickwork. To obtain a satisfactory result, bricks should never be laid in freezing weather. If the temperature is much below 40° F. during the day, so that it is likely to freeze during the night, salt may be mixed with the mortar and the top of the wall well covered with boards and straw, and if the upper courses are found to have been frozen over night they must be taken down and re-laid, as the alternate freezing and thawing will materially damage the strength of lime mortar and will entirely ruin mortar made of natural cement of the Rosendale type. "Mortar made of one part of Portland cement and three parts of sand is entirely uninjured by freezing and thawing." If it is absolutely necessary that brickwork should be laid in freezing weather with natural cement mortar, it may be done by mixing the mortar "with water to which salt has been added in the proportion of one pound of salt to eighteen gallons of water, when the temperature is at 32° F. and, for each degree of temperature below 32°, add three additional ounces of salt. Mortar mixed with such a solution does not freeze in ordinary winter weather, and hence is not injured by frost." In addition to this, the bricks should be warmed to remove any ice or frost.

These methods may be used in emergencies, but the laying of bricks in freezing weather is not to be recommended, if it can be avoided.

Arches. In the erection of brick walls, especial care should be given to the construction of arches which will be necessary to span the openings. Arches, in general, should be laid in cement mortar. The two principal forms of arch in brickwork are the *rowlock arch*, where the bricks are laid in concentric rings of headers, Fig. 114, and the *gauged arch*, where the bricks are cut and bonded on radial lines, as in Fig. 115. For arches of large spans the bricks are often laid in rings of stretchers, Fig. 116, and, if the span is very large, these may be strengthened by bonding in headers as in Fig. 117. An important point in the use of arches is to see that each abutment contains sufficient masonry to support the thrust of the arch; tie rods should be freely used in case of any doubt, and arches of large span should be sprung from stone skewbacks carefully cut to radial lines, as in Fig. 118.

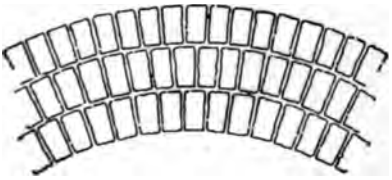


Fig. 114. Rowlock Arch.

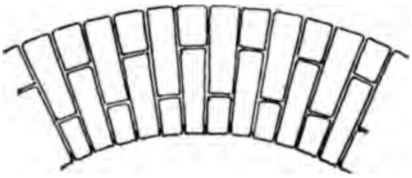


Fig. 115. Gauged Arch.

Mortar. All mason-work below ground should be laid in cement mortar, and all arches or heavily loaded piers as well. In many city laws, the use of cement mortar is required to a certain proportion of the height of wall. Cement mortar of some kind should be used for setting cornice stones and wherever the work is especially exposed. For all work under water, for large arches and for tops of chimneys, Portland cement should be used, and Portland cement may be mixed with Rosendale to make a strong, quick-setting mortar. Portland cement and lime may be mixed to give a strong light-colored mortar which is much used in England for face-brick work.

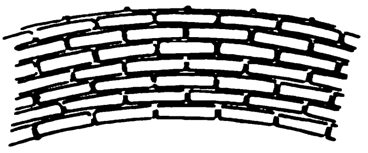


Fig. 116. Arch of Stretchers.

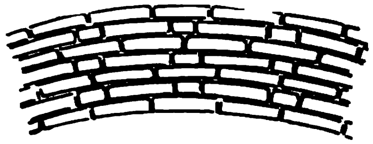


Fig. 117. Bonded Stretchers in Arch.

Sand. The proportion of sand used in mortar should vary with the kind of cement and the use for which the work is intended. With Rosendale cement, the proportion of sand should not exceed three to one, and for piers two to one. Portland cement may contain sand in proportion of four to one, and lime mortar three to one. The object of using sand in mortar is to prevent too much shrinkage, and as a cheaper material than lime or cement, its functions being mechanical rather than chemical. It strengthens lime mortar, by supplying a base to which the particles of lime adhere more firmly than to each other, but its presence in cement mortar is a weakness. In all cases a thorough mixing is essential, the object being to so thoroughly mix the particles that no two grains of sand shall lie against each other without a film of cement between. The cement and sand should be mixed dry, the process being to spread them in layers and then turn and work the mass until it is thoroughly mixed,

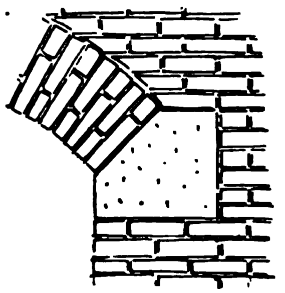
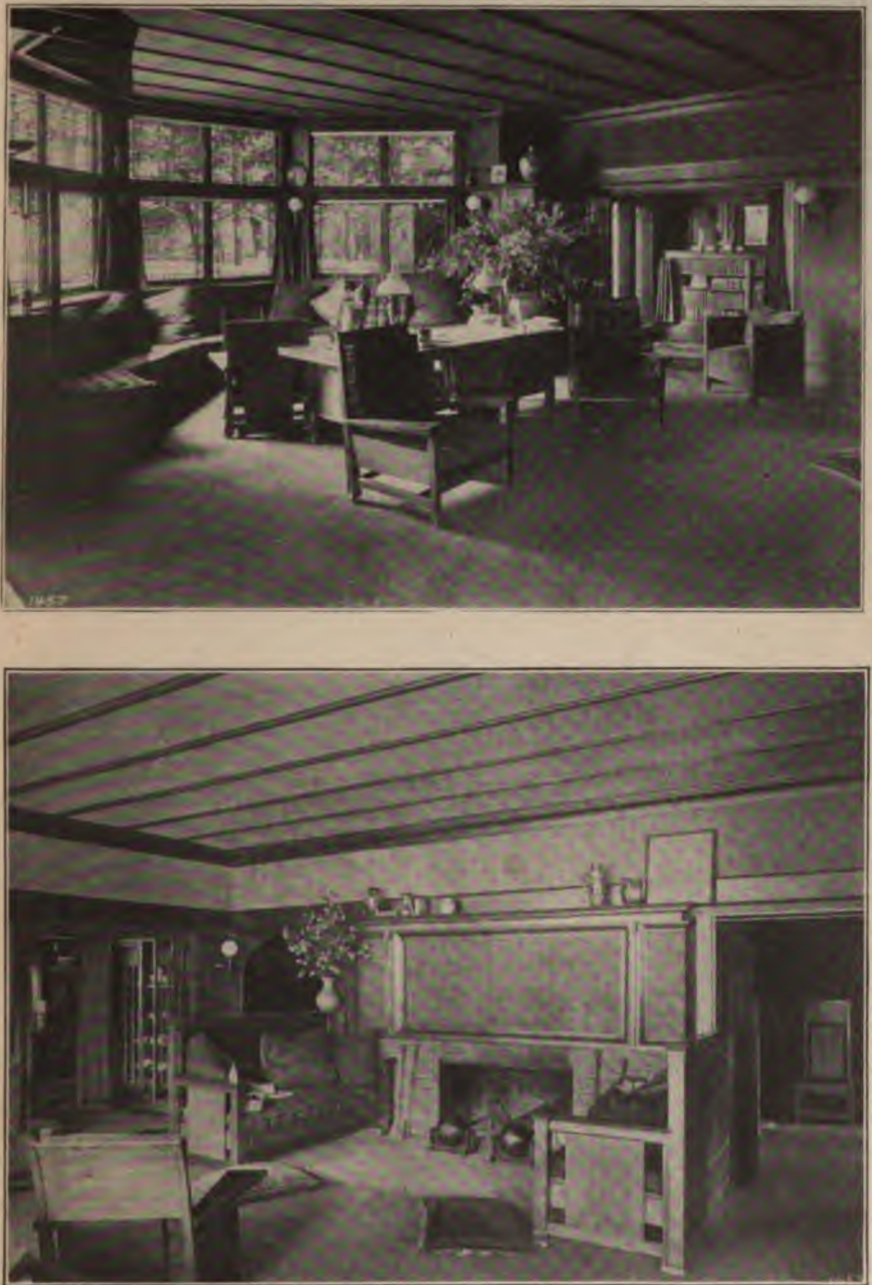


Fig. 118. Stone Skewback.



TWO VIEWS OF LIVING ROOM IN RESIDENCE OF MR. B. H. BRADLEY, KANKAKEE, ILL.
Frank Lloyd Wright, Architect, Oak Park, Ill.
Woodwork of Fumed Oak; Brick, Brown. Built in 1901.

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when water is added in sufficient quantity to obtain mortar of the desired stiffness.

If too much sand is added the mortar will stick to the trowel and will not work easily. The superintendent should become, as soon as possible, familiar with the appearance of good mortar so that he can tell readily whether too much or too little sand has been added. If the mortar slides easily from the trowel it is usually of the right proportion. In ordinary practice, the lime and sand are mixed as soon as the lime is slaked and allowed to stand until needed, but it is better not to mix the sand until ready for use. Coarse sand makes a stronger mortar than fine sand, and a fine, loamy sand, although it works easier than sharp coarse sand, does not make a strong mortar.

LIME AND CEMENT.

Lime is now manufactured in nearly all parts of the country, but differs in character in different localities. In using a lime which is not already familiar, some inquiry should be made as to its properties, especially if used for plastering. Good lime in general should be free from cinders or clinkers, and with less than 10 per cent of impurities, and should be found in large lumps which will slake readily in water, making a soft paste, free from residue or "core." It should further completely dissolve in soft water. Slaked lime, or "lime-putty," as it is commonly called, will keep indefinitely if protected from the air so that it does not dry up. This is usually done by covering it with sand in the bed in which it is slaked. Lime, before slaking, will absorb moisture from the air and become "air-slaked;" this destroys its strength and care should be taken that all lime is carefully protected from dampness until used.

Setting and Durability. Lime mortar does not possess the "setting" quality of cement, but gradually hardens by exposure to the air. Lime mortar does not harden under water or in very damp situations, but in dry places where there is ample exposure to the atmosphere, it will set hard enough for all ordinary uses of brickwork, except arches and piers, and where excessive loads may be applied.

Hydraulic Lime and Cement. Some limes, after burning, contain enough clay or silica to acquire the property of setting under water and are called hydraulic limes, but are used to very little extent, as their qualities are more easily and profitably obtained by the use of cement, which is now more readily obtained, although hydraulic lime was formerly imported from England and France. Cement may be put in two classes—natural cement and artificial cement. Natural cement is obtained by burning limestones which contain a large proportion of clay. This forms a powder which, when mixed with water, sets quickly either in air or water. Natural cements are made in many localities throughout the country, Rosendale cement being probably the best known brand, and this is usually of good quality and easily obtained. Of artificial cements the best known is Portland cement; this is of English origin and derives its name from the resemblance of a trowelled surface, to Portland stone, one of the best known building stones of England.

Portland cement is made by combining proper proportions of carbonate of lime, clay, silica and iron. This mixture is dried and then burned into a heavy vitreous "clinker," which is afterward ground to a powder and run through fine sieves to make the finished product. Portland cement is now manufactured in many parts of the United States, and of as good a quality as the imported cements. Portland cement does not set as quickly as common cement, but possesses greater strength. There is now upon the market a grade of Portland cement known as "sand-cement" in which a certain proportion of sand is mixed with the powder and the whole ground to the fineness of the cement; this requires less sand in the final composition of the mortar and is productive of satisfactory results. Another prepared cement of a nature similar to Portland cement is known as Lafarge cement, and is useful in setting limestone or marble, as it does not stain like ordinary cement.

Color. Some idea of the quality of cement may be obtained by a familiarity with its appearance upon opening the cask. With common cement the darker brown colors, in general, indicate the stronger qualities. Too dark a color, however, may indicate, in an unfamiliar brand, the presence of coloring matter, usually lampblack. This may be detected by putting some of the cement into a glass of water, when the lampblack will separate as a black scum. With Portland cement, a clear grey or bluish-grey color is to be preferred, as a brown color is given by an excess of clay, while too much of a bluish cast indicates the presence of too much lime. Further tests of cement may be made as described in Part I. for ordinary work, but for important engineering works where Portland cement is used, it should be subjected to careful tests for activity, soundness, and strength, both unmixed and mixed with sand.

In general, to obtain the best results, the superintendent should choose a fine, well-burned cement of average specific gravity, and, for important work, test it frequently. This, mixed with a sand that has passed a careful scrutiny for cleanliness and regularity, should give a smooth and strong mortar.

Protection. Whether lime or cement mortar is used in the building of a wall, it should be kept at all times protected from the weather until the mortar has become thoroughly set.

Brick Veneer. In some localities, dwellings and light mercantile or public buildings are built with a frame of studs and boarding, veneered on the outside with four inches of brick. In this construction, the strength of the building lies in the frame, and the superintendent should see that this is built and braced in the best manner, plumb and straight and boarded diagonally, all of well-seasoned stock. Over the boarding, tarred felting should be placed, and an inch away from this, the four-inch brick wall, tied at short intervals to the wooden wall, as shown in Fig. 119. A metal tie such as at A may be used or the patented tie B, which is better.

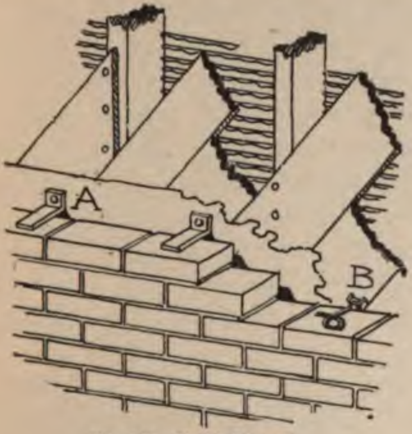

Fig. 119. Brick Veneer.

As moisture will collect in the air space behind the veneer, the ties will be better if given a drip, as for hollow walls, and a small drain may be laid at the top of the foundation wall connected with the cellar by pipes for drip and ventilation. This combination of masonry and woodwork is not to be recommended in general, but should only be used as a matter of economy.

The use of wood in the structure of brick walls, while sometimes necessary, should be avoided where possible. Wooden lintels were formerly used to considerable extent, but are objectionable for many reasons. Besides being combustible, it is almost impossible to obtain beams, of the large size which their purpose requires, which are dry, and the shrinkage is pretty sure to make a crack at some time. (Fig. 120.) Wooden plates inserted in the wall, for a level bearing for floor timbers, should be avoided, as their shrinkage will leave the bricks above unsupported. Wooden lintels may be used under arches to form a square opening, but the arch should always spring from the solid wall beyond the lintel to relieve it from the load above. (Fig. 121.) Wooden strips are sometimes built into the walls for a nailing for furring and finish, but, if used, should be thin enough to lay in the joint; and wooden bricks, often used for nailings, by their shrinkage will become loose besides weakening the walls.

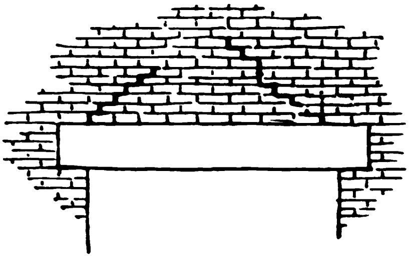
Fig. 120 Wooden Lintel.

A better way is to use a strong mortar into which the nails of the furring strips may be driven or porous terra cotta blocks may be set for nailings in special work.

Cleaning Down. When a piece of brickwork is completed, the exterior will need to be cleaned of mortar stains and discolorations. This is done by washing down the wall with a dilute solution of muriatic acid, using a scrubbing brush, followed by washing with clear water to remove all trace of the acid. The wall is then often given a coat of linseed oil cut with turpentine. At this time also, all bad joints are pointed up, the spaces under window sills are filled up, the joints of stonework pointed, and the wall left whole and clean.

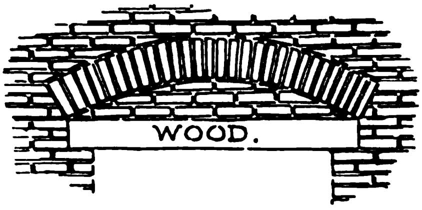

Fig. 121. Relieving Arch.

Waterproofing of Walls. Brick walls in exposed situations are often treated with some substance to render them waterproof. One of the most successful processes is known as "Sylvester's Process," and consists in applying two washes to the walls, one composed of Castile soap and water, and the other of alum and water. These applied alternately will generally render the work impervious. Several patented solutions are now upon the market, each of which is warranted to protect against moisture.

Efflorescence. Very disagreeable and very common is the white efflorescence which often appears upon the face of the bricks, due to the salts of soda and potash being dissolved by the water and left on the surface by evaporation. Sylvester's solution is a preventive of this, applied in the same manner as for waterproofing, and the danger may be diminished by using stronger cement in the face joints.

Repairs. In effecting repairs in masonry, when new work is to be connected with old, the mortar of the old work must be thoroughly cleaned off, along the surface where the junction is to be made, and the surface thoroughly wet. The bond and other arrangements will depend upon the circumstances of the case. The surfaces connected should be fitted as accurately as practicable, so that by using but little mortar, no disunion may take place from settling. As a rule, it is better that new work should butt against the old, either with a straight joint visible on the face, or let into a chase, sometimes called a "slip-joint" (Fig. 122), so that the straight joint may not show, but, if it is necessary to bond them together, the new work should be built in a quick-setting cement mortar, and each part of it allowed to set before being loaded. In pointing old masonry, all the decayed mortar must be completely raked out with a hooked iron point, and the surfaces well wetted before the fresh mortar is applied. Lining of old walls should be not less than eight inches thick, anchored every two feet.

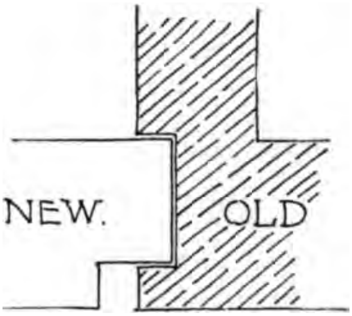

Fig. 122. Slip Joint.

Superintendence. In superintending brickwork, the main things to be observed have been pointed out in connection with the construction. Especial care should be taken to see that the bricks are properly wet, that sufficient mortar, of the proper quality, is used, and that the joints are thoroughly filled. The bonding of the wall must be constantly noticed, especially face work and piers. The work should be measured from time to time and the position of all openings noted. Reveals and jambs should be measured and plumbed, and the leveling of courses carefully watched. At the level of the floors, the bedding of all bearing plates must be watched and the number and position of floor and wall anchors noticed. Recesses and flues should be carefully followed out, and the tying together of hollow walls should be frequent and effective. When work is stopped, the top of the wall should be covered, to prevent rain from washing out the soft mortar in summer, or from entering and freezing in winter; and to obtain the best results, the laying of brick walls should not be attempted in freezing weather.

For the adaptation of brick construction to modern city building, we may conceive the foregoing principles as elements to be applied to the different conditions and uses to which the walls will be put.

Bearing walls are those which carry besides their own weight the weight of floors or roofs which bear upon them. The thickness of these walls must necessarily increase as does the height of the building, and they must also be strong enough to brace the building against lateral forces such as wind pressure, or the vibrations from external or internal sources.

Curtain walls are those built between steel or iron columns, or between piers, and carry no loads except their own weight. Their thickness needs to be only such as to protect the outside of the building and give support to walls above.

Skeleton construction has all walls, as well as other parts of the building, supported by steel or iron columns and beams. In this case the masonry needs to be only of sufficient thickness to protect the building and the frame against the elements, unless these walls are depended upon for stiffening and bracing the building. The exterior walls may be of brick, concrete, terra-cotta, or other fire-resisting material, depending in a measure upon the location, custom, experience of builders, and the influence of union labor in various localities.

In the case of a skeleton frame, the walls of each succeeding story will be supported independently and may be considered as curtain walls. At the present standard prices of materials, a building for ordinary floor loads can be erected eight stories high, with continuous bearing walls of masonry, more cheaply than with piers and curtain walls or skeleton construction. If, however, the extra land area, which the thicker bearing walls will require, is of value enough, it will be economy to use skeleton construction for six or even five-story buildings, depending largely upon the character and location of the building.

CUT STONEWORK.

First in consideration of the superintendence of stonework is the preparation of the material. In former times, for a work of importance, the stone was often brought to the building site in the rough, as it came from the quarry, and all stone cutting was done upon the spot, but in modern practice the stone will be prepared at a stone yard, often by machinery, and will be ready to be set when received. The stone should be carefully examined *when delivered* and not be allowed to accumulate in great quantities without inspection, as a thorough examination is then more difficult. According to the nature of the work, the stone will have received more or less of preparation by being worked into the various shapes and finishes suited for its purpose.

Stock. The principal building stones in use in this country are granite, limestone, marble and sandstone, and these will be selected for a given building with reference to color, durability and strength. Probably the question of color will enter more strongly into the selection than any other consideration, but this should not wholly overshadow the consideration of strength and durability. Cheapness and accessibility are factors which enter largely into the question of stone for a building, and in cities, the resistance to atmospheric action and especially to fire, may well be considered. While no building stone will resist the action of fire for any length of time, of the different kinds of stone mentioned, fine-grained sandstone will probably stand the best, granite next, and marble and limestone the least.

Testing of Stone. Although it is possible in most cases to obtain stone for a building from some well-known quarry, the qualities of which have been sufficiently proved, occasion may arise when some simple tests of a certain stone may be desirable. These tests should be made for compactness, absorption, strength and fracture. The compactness of a stone can be best determined by comparison with some known stone of similar constituents, when the least porous in appearance will usually prove the most durable. The porosity may be determined by the power of absorption which it exerts. This may be found by immersing the thoroughly dried stone in water, and noting the difference in weight between the dry and the wet stone. The absorption of ten per cent of the weight of the stone denotes a degree of porosity which is liable to become, after a while, grimy in appearance, while a hard non-absorbent stone suffers little from age.

In situations where the atmosphere is charged with acids, as in large cities or manufacturing towns, there will be danger from the solubility of the stone, especially in damp climates. Too great a tendency may be discovered by soaking the stone in a dilute solution of acid, or by dropping acid upon the surface, when presence of soluble carbonates will be denoted by an effervescence. The presence of substances easy of solution in water, may be detected by placing some of the powdered stone in a glass with water and allowing the particles to settle. If the water is later disturbed, the presence of soluble matter will cause the water to turn muddy, but if the water remains clear it will denote the presence of only insoluble crystals.

FINISHING OF STONE.

The method of finishing a stone has a great effect, not only upon its appearance, but upon its durability. The less pounding a stone receives the stronger it will be, since the repeated jar tends to separate the particles and render the stone less durable. For this reason it is only granite and hard sandstones that are usually treated by hammering the surface, the softer stones being generally finished by the use of some form of chisel.

Tools. The principal tools used in stone-cutting are:

1. The axe or pean hammer. This is a solid tool with two cutting edges, and is used for making the draft line or margin on granite and in leveling off the face. (Fig. 123A.)

2. The tooth axe is similar to the axe, except that the cutting edges are divided into teeth. This is used on sandstones as well as on granite. (Fig. 123B.)

3. The bush hammer, a square head cut into a number of points. This is used for finishing sandstone and granite. (Fig. 124A.)

4. The crandall, an iron handle with a long slot at one end into which are wedged a number of double-headed points. These points are secured by a key and may be removed for sharpening.

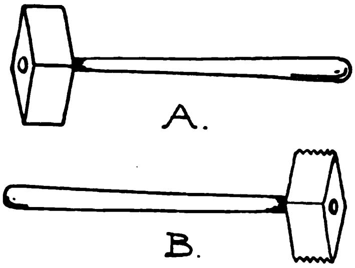

Fig. 123. Axe and Tooth Axe.

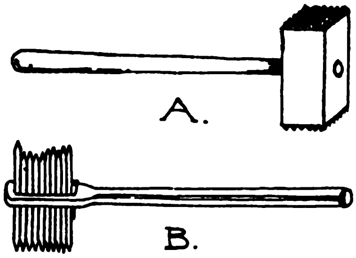

Fig. 124. Bush Hammer and Crandall.

This is a common way of finishing sandstone after the surface has been leveled by means of a tooth chisel. (Fig. 124B.)

5. The patent hammer, a hammer formed of a number of thin blades of steel which are bolted into a heavy head, and used for finishing granite and hard sandstones. (Fig. 125A.)

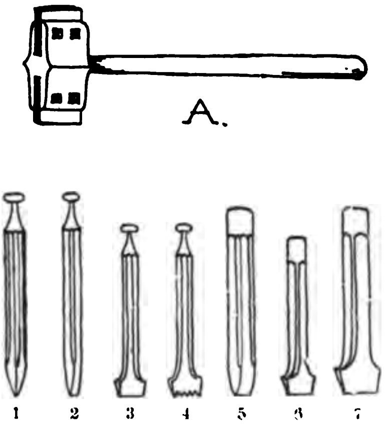

Fig. 125. Patent Hammer and Chisels.

6. Chisels of various form, among which are to be found the point No. 1, chisel and tooth chisel Nos. 2 and 3, the drove No. 4, all for use with a mallet, the hammer chisel No. 5, and pitching tools Nos. 6 and 7. (Fig. 125.)

Finish. The simplest of the various finishes which are given to cut stone is the *rockface*, shown in Fig. 126. In this, the face of the stone is left rough, the edges being pitched off to a line. A margin or draft line is often cut around the edge, leaving the center with rockface. (Fig 127.) Pointed work (Fig. 128) is done by taking off the surface of the stone with a point, and is made rough or fine-pointed according to the position or importance of the stone. This is used mainly in granite, a similar effect being obtained in soft stones by use of the tooth chisel. Tooled work (see Fig. 129) is done in straight lines clear across the face of the stone and is used a great deal for sandstone and limestone.

Bush hammering, as its name implies, consists in hammering the stone, usually granite, with a bush hammer, leaving the surface covered with points.

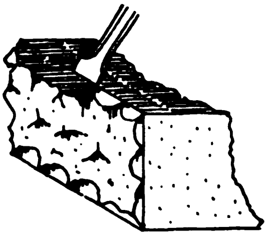
Fig. 126. Pitching off for Rock Face.

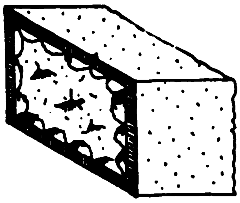
Fig. 127. Rock Face with Draft Line.

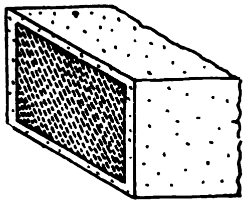
Fig. 128. Pointed Work.

Patent hammered work, Fig. 130, leaves the surface covered with a series of ridges and is known as "six-cut," "eight-cut," or "ten-cut" work, according to the number of points to the inch. This is a usual finish for granite and is generally called for as "eight-cut" work. Crandalled work, Fig. 131, is used for sandstone more than any other finish, and consists of a series of lines crossing each other, or running all one way, according to whether the crandall is used from one side or from both. If a smooth finish is desired the stones may be rubbed. This is easily and cheaply done when the stone is first sawed, and makes a good finish. Vermiculated work, shown in Fig. 132, is obtained by working the surface all over in imitation

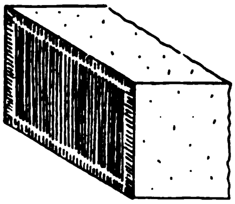
Fig. 129. Tooled Work.

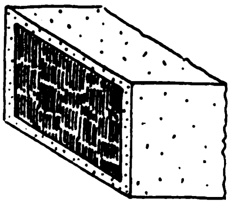
Fig. 130. Patent Hammered Work.

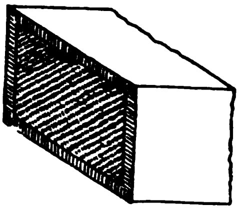
Fig. 131. Crandalled Work.

of the destruction by worms. This is expensive and is rarely used except for quoins.

The inspection of stone at the building should be very thorough especially in the matter of finish. The finer the degree of finish, the more costly will be the labor, and for this reason there is often a tendency to slight the work. Eight-cut granite will often be found to be six-cut, and fine-pointed or fine-crandalled work will sometimes be found to be rough and coarse.

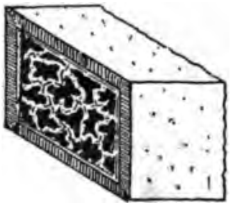

Fig. 132. Vermiculated Work.

STONE MASONRY.

Rubble. Of the different kinds of stonework, rubble masonry requires less preparation of the material than any other use of the stone, and covers a wide range of construction, from ordinary foundation walls, such as we have already considered, to the handsome well-pointed masonry of churches and other buildings.

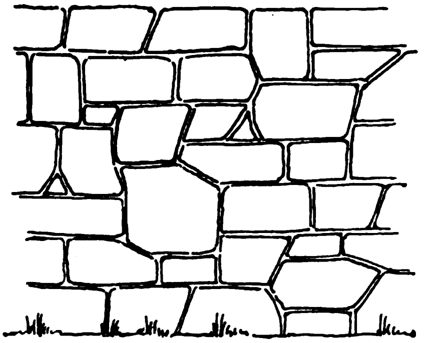

Fig. 133. Uncoursed Rubble.

Two definite classes of rubble work are recognized: (1) uncoursed rubble, in which stones of irregular shape are laid as they come to hand with no attempt at level courses, as in Fig. 133; and (2) coursed rubble, in which the blocks are levelled off at regular heights to a horizontal bed, as in Fig. 134. A wall of rubble is finished by pointing up the joints with cement mortar colored to taste, usually to the same color as the stone, when this is at all even colored. Sometimes a false joint of red or white mortar is run upon this pointing to imitate ashlar work.

Uncoursed rubble is sometimes laid with irregular pieces having hammered joints which are fitted together with no "spalls," or small stones, between. (Fig. 135.) This is an expensive and tedious process but is very effective when well done. The coursing of rubble is not necessarily uniform, or at the same level throughout, but may rise and fall by level stages to accommodate the size of the materials.

The superintendence of this class of work, beyond a general inspection of the quality and soundness of the stone, will be mainly to see that the stones are well laid after being suitably prepared by roughly squaring with a hammer, and knocking off all weak angles and projections. The stones should be clean and free from dust, and should be moistened before laying. Mortar should be used in sufficient quantities to permit of each stone being firmly imbedded, and all hollows between the large stones should be filled with small stones carefully bedded in the mortar. All large stones should be laid on their natural bed, and should be so used that the side parallel to the bed shall be the largest, so that the stones shall lie flat and in no case be set on edge or on end. Care must be taken to break joints, and no side joint should form an angle with the bed of less than 60 degrees.

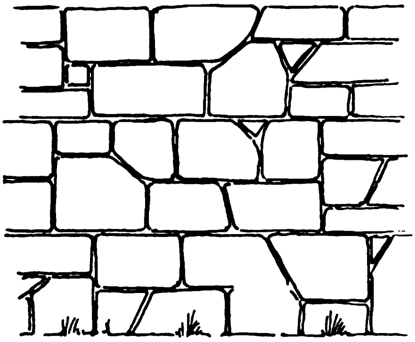
Fig. 134. Coursed Rubble.

The bonding of a rubble wall must be carefully watched, and bond stones freely used. If the rubble is backed with brick, as is often the case, iron clamps and ties should be inserted, which may run through the wall and turn up up behind the brick, if the back of the wall is to be concealed, and they should run to the inside course of bricks in any case. (Fig. 136.) If rubble is used as a backing for cut stone, the facing should contain a large proportion of thick stones which will bond well with the rubble. These bond stones may be left rough at the back and sides, but the upper and lower beds should be level, so that they will have

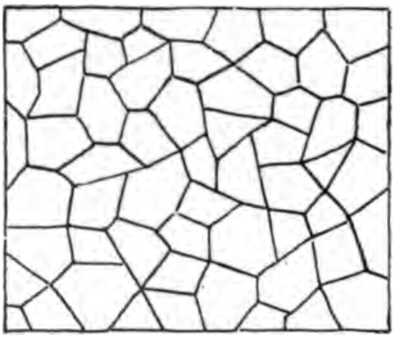
Fig. 135. Hammered Joints with no "Spalls."

no tendency to wedge off the backing. This backing should be carried up at the same time as the face work with the coursing leveled off at the same place. A good proportion of thick stones running two-thirds or more across the thickness of the wall is better than a few extending through the wall.

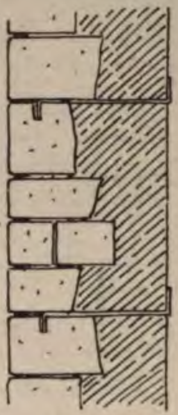
Fig. 136. Iron Ties.

Ashlar Masonry consists of blocks of stone which have been cut to a regular figure, generally rectangular in shape, and laid in courses of usually a foot or more in height. (Fig. 137.) If the courses are not maintained at the same level continuously, but are laid of stones of unequal height but still level and plumb, the work is called "broken ashlar," shown in Fig. 138.

In all ashlar work of soft material, such as limestone, no stone should have a length greater than three times its height. In harder stone the length may be four or five times the height. The thickness in soft stone may be once-and-one-half or twice the height; in hard stone, three times the height.

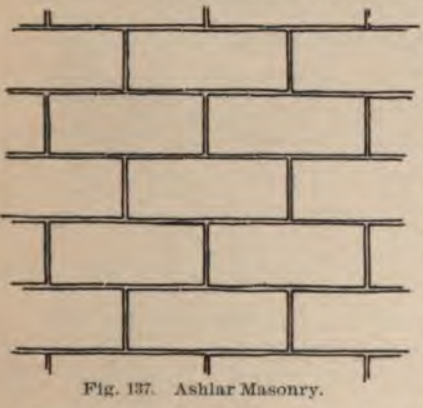
Fig. 137. Ashlar Masonry.

Laying. The bed upon which the stones are laid should be level, and cleared of dust or refuse, and well moistened with water. Upon this the bed of mortar is spread evenly. Wooden wedges of the thickness of the joint are then laid on the face of the bed, and the stone carefully lowered upon the wedges, to be moved into exact position by the aid of a "pinch bar." In using a bar or rollers in handling cut stone, it will be necessary to protect the edges of the stone by bagging or other "softening." When the stone is in its final position, the wedges may be removed and the stone settled into place and leveled by striking with a wooden mallet. In the case of heavy stones where there would be danger of the weight of the stone squeezing the mortar out of the joint, the wooden wedges are allowed to remain until the mortar has set. The bed of mortar should be kept back an inch or so from the face of the stone, so that the stone shall not bear on its outer edge. This will save raking out the mortar when the wall is to be pointed, and will prevent any danger of the splitting off of "spalls" on the face, which might occur on account of the mortar on the face of the joint becoming hard sooner than the inside, when the unequal settlement would bring pressure on the edge of the stone.

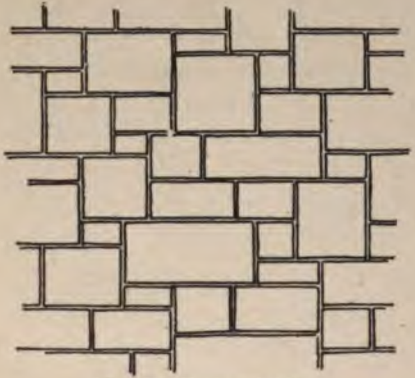
Fig. 138. Broken Ashlar.

The same defect may occur if the bed of the stone is cut hollow or slack, as in Fig. 139, when the settlement of the mortar will bring the whole pressure upon the front edge of the stone with the same result. For this reason, care should be taken that the bed joints are square and true. Door and window sills should be bedded only under their ends, as the natural settlement will cause them to break if bedded under the opening. (Fig. 140.) Stone work in damp situations should be set in cement mortar, but lime may be used if the situation is dry. Limestone and marble, and some sandstones, are often badly stained by the use of cement mortar, and inquiry in respect to this should always be made before using an unfamiliar stone.

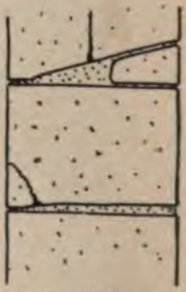
Fig. 139. Hollow and Slack Joints.

In case of danger from this source, Lafarge cement, a cement made of lime, plaster of Paris, and marble dust, may be used, which should be plastered over the back of the stone as well, if cement must be used in the backing.

Bonding. Care must be taken that no vertical joint in any course comes over a joint in the course below, but the stones should break joints or overlap, preferably to an extent of from once to once-

and-a-half the height of the course, so that each stone will be supported by at least two stones of the course below, and will in turn support at least two stones of the course above. This will not only distribute the pressure of the weight above, but will tie the wall together in its length, by means of the friction of the stones where they overlap. For the same reason, the thickness of the stones should vary, so as to make a bond in and out of the wall, as in Fig. 141, and at least one stone in every ten square feet of wall should be the full thickness. The strongest bond in a wall of cut ashlar is one in which each course contains a header and stretcher alternately, the outer end of each header coming on the middle of the stretcher. (Fig. 142.) In broken ashlar work the bond should be carefully preserved, and, in the case of broken ashlar used with a brick backing, it will be convenient to use stones of a thickness of four, eight, and twelve inches, alternating, so that the bond may be obtained through and through without much cutting of the bricks.

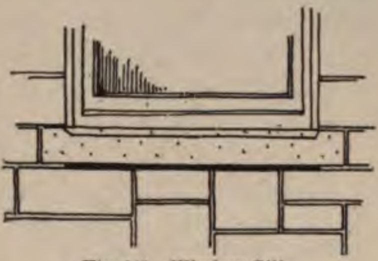
Fig. 140. Window Sill.

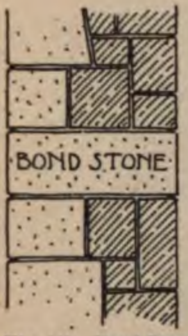

Fig. 141. Bond Stone.

In the backing of ashlar, the joints of the brickwork should be made as thin as possible, and cement should be used to prevent shrinkage of the joints, which will necessarily be more numerous than the joints of the ashlar facing. Brick backing should not be less than eight inches thick, and, if the facing is in courses exceeding a foot in height, each large piece should be tied to the brick by iron clamps in the proportion of about every three feet in the length of the wall, and two feet in the height. It will be of

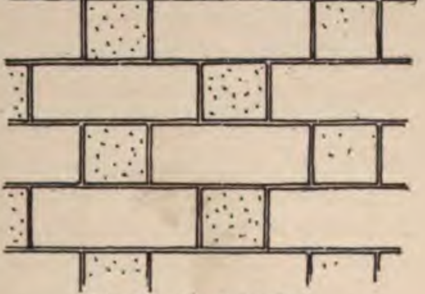
Fig. 142. Bonded Ashlar.

advantage in this class of work if the horizontal joints are not allowed to run to a great length. Changing the level of the courses every four or five feet will make a good looking wall. Broken ashlar is usually prepared at the building site, but it will be a saving if the stones are cut to the required heights in the yard, leaving only an end joint to be cut at the building.

Quoins, Jambs and Lintels. The corner stones of a building are called quoins, and they are often given prominence over the face of the wall, as in Fig. 143. In broken ashlar the quoins should be as large in height as the largest of the wall stones. Stones at the sides of openings are called jamb stones and are often used in a manner similar to quoins. Lintels or caps are the stones which cover door or window openings. They are usually in one piece, as in Fig. 144 A, but are sometimes necessarily jointed. (Fig. 144 B.) In this case the joints should be "toggled" as shown. If the lintel spans an opening which is too great for its carrying capacity, it may be assisted by the use of a steel angle-bar or beam. (Fig. 145.) Lintels should bear at the ends at least four inches, and in the case of the lintel being thicker than the jamb, it should have bearing enough to reach beyond any recess which the window frame may require, as in Fig. 146, so that the inside of the lintel will be supported.

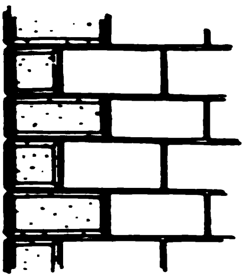

Fig. 143. Quoins.

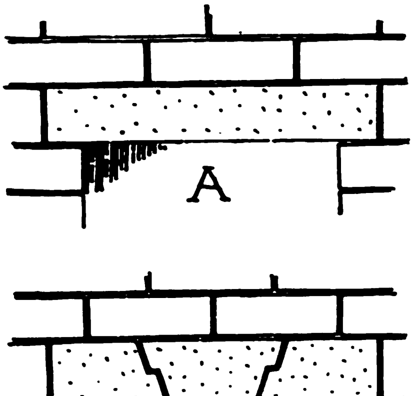

Fig. 144. Stone Lintels.

Columns, Arches and Trimmings. Columns, where the material will allow, should be cut in one piece with separate capitals and bases, and great care should be taken in cutting, and also in setting, to have the bed joints perfectly level to the axis of the column. Clear cement mortar should be used for setting, and especial care taken to keep the outside of the joint empty for a depth of at least three-quarters of an inch, to prevent chipping the column. Lintels or cornices over columns are often exposed on both sides and should be cut from one stone if practicable; if not, they may be built up as shown. (Fig. 147.) In this case the stones should be carefully tied and clamped together.

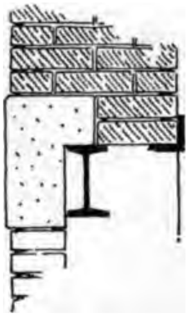
Fig. 145. Steel Support of Lintel.

Arches, if too large to be cut with solid stones, may be built up where they are required to show both sides. (Fig. 148.) In the setting of stone arches great care is necessary to preserve the perfect form of the arch. The joints should always be of equal thickness throughout and the mortar kept back from the face. This is of greater necessity than in the horizontal courses, as the joints of the arch are under increased pressure. The backing of arches should be laid in cement, and well tied to the stones of the arch by clamps. Where two arches come together, the first stone, called the "skewback," should be in one piece for the two arches (Fig. 149), for if each stone were cut to the shape of its arch there would be left a small wedge-shaped stone, A, which, if separate, might crowd the arch stones in. The same thing should be done where an arch comes near to a corner as at B.

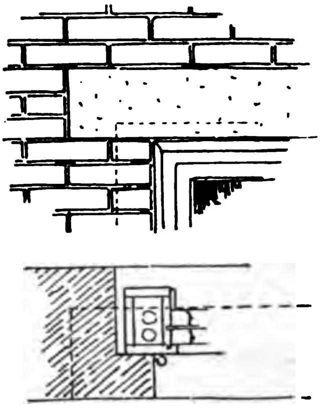
Fig. 146. Bearing of Stone Lintel.

Flat arches are often used, but, while they are architecturally pleasing, they are liable to constructional weakness, and if they cannot be given a good height, they should be cut as a lintel with false joints on the face. If the opening is not wide, a flat arch may be cut in three pieces, the key with its side pieces being separate from the other two pieces, as in Fig. 150. In this case, and also in the case of B in Fig. 144, the center should be set about a quarter-inch higher than the jambs, to allow for settlement.

Centering. For the construction of arches, whether of stone or other material, wood centers will be required. These should be strongly made and should be left in position until the mortar in the joints has become hard. Centers for small arches are usually made of plank, with two ribs set apart to the thickness required, and connected for a bearing surface by strips of $\frac{7}{8} \times 2$-inch stick nailed to the tops of the ribs. A center of this sort is supported by wooden posts from the sill or floor below. If the arch is of a large span, the pieces will be more in number, in order to use planks of ordinary width, and the center will need additional support and ties as shown by Fig. 151. These centers should be wedged up in setting, to permit of easy adjustment or removal.

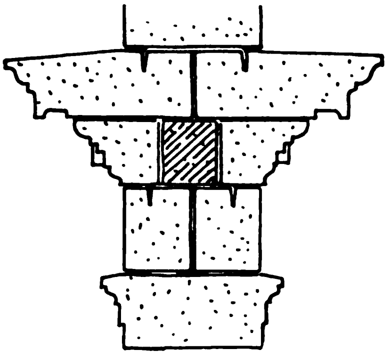

Fig. 147. Built-up Cornice.

GENERAL RULES FOR LAYING STONE.

1. Build the masonry, as far as possible, in a series of courses, perpendicular, or as nearly so as possible, to the direction of the pressure which they have to bear, and by breaking joints, avoid all long continuous joints parallel to that pressure.

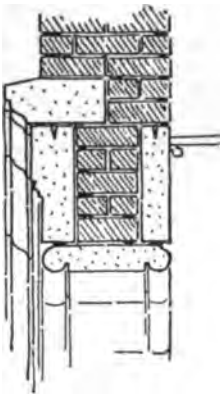

Fig. 148. Construction of Arch.

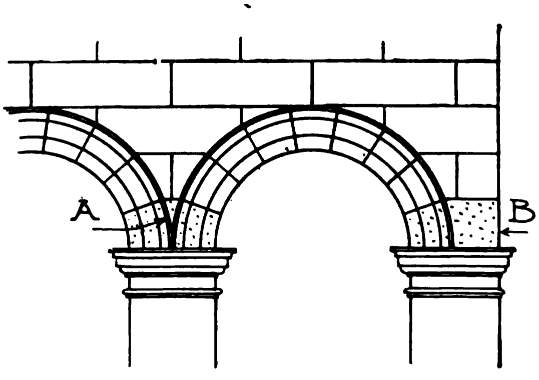

Fig. 149. Solid Skewbacks.

2. Use the largest stones for the foundation course.

3. Lay all stones which consist of layers in such a manner that the principal pressure which they have to bear shall act in a direction

perpendicular, or as nearly so as possible, to the direction of the layers. This is called laying the stone on its natural bed, and is of primary importance for strength and durability.

4. Moisten the surface of dry and porous stones before bedding them, in order that the mortar may not be dried too fast and reduced to powder by the stone absorbing its moisture.

5. Fill every part of every joint, and all spaces between the stones, with mortar, taking care at the same time that such spaces shall be as small as possible.

6. The rougher the stones, the better the mortar should be. The principal object of the mortar is to equalize the pressure; and the more nearly the stones are dressed to closely fitting surfaces, the less important is the mortar. Not infrequently, this rule is exactly reversed; *i.e.*, the finer the dressing, the better the quality of the mortar used.

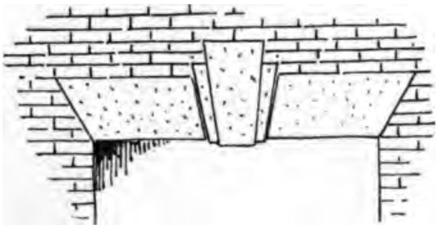
Fig. 150. Flat Arch of Stone.

All projecting courses, such as sills and lintels, should be covered with boards, bagging etc., as the work progresses, to protect them from injury and mortar stains. When setting cut stone, a pailful of clean water should be kept at hand, and when any fresh mortar comes in contact with the face of the work it should be immediately washed off.

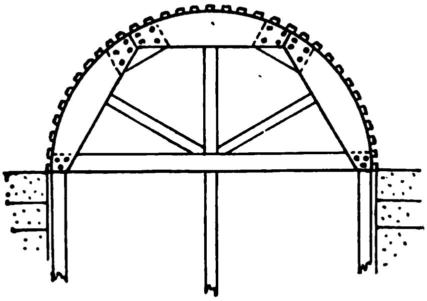
Fig. 151. Wooden Centering for Arch.

General Inspection. The superintendence of cut stone-work requires constant attention, as it is expensive and annoying to be obliged to remove a stone after it has been set in the wall. There are also many devices by which defective stock and workmanship may be concealed, which can only be avoided by vigilance and the exercise of considerable knowledge of practices.

The first thing necessary is a thorough inspection of the stone as delivered, and a careful search for defects which are known to be likely to occur in the various kinds of stone.

Granite often develops local defects, such as seams, knots, or brown stains known as sap. The latter will be apparent upon examination, but seams are to be detected by striking the stone with a hammer, when a flawless stone will ring clearly.

Sandstones will often be found with small holes, called sand holes, and of an uneven color; there will also be local discolorations which are sometimes developed by cutting, and do not appear until so much expense has been put upon the stone that the contractor is often tempted to pass it as perfect if he can do so. Considerable firmness may be necessary to obtain work in exact conformity with the specifications, but this should be insisted upon at all times. Another defect which requires the exercise of great judgment is the matter of patched stones. Expensive stones are often marred by the cutting or handling, and are then so skilfully patched by the use of melted shellac and stone dust, that they may be overlooked until set, when they often cannot be replaced without considerable delay. In this case, if the owner agrees, they may be allowed to remain, but the superintendent should see that the patching is properly done. Where a moulding in this case has been knocked off and simply stuck on again with shellac, the superintendent should insist that a square block should be dovetailed in and the moulding re-cut.

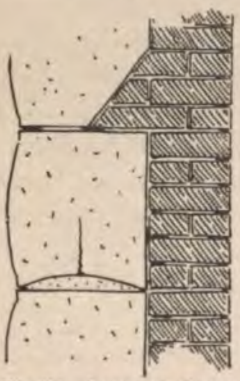
Fig. 152. Improper Stone Cutting.

In the dressing of the stone, care should be taken to see that the work is as finely cut as called for, and mouldings should be cut according to details and matched together perfectly. Ashlar work should be cut with full bed joints without hollows or thin edges (Fig. 152), and should be cut so as to lie on its natural bed. Anchors should be freely used, and the bonding of ashlar and backing carefully watched. The setting of columns, arch stones, and moulded work should be especially noted to see that the mortar is kept well back from the edges to prevent their splitting off, and the tying of continuous courses to each other at the ends should be insisted upon. Projecting courses must be bevelled off on the top to shed water and should also have a drip cut on the under side, so that the water will drop off and not run down the side of the building. (Fig. 153.) The bed which lies in the wall, however, must not be bevelled, but must be cut level to maintain the full bearing of the stones in the wall.

Pointing. When the exterior masonry of the building is done, the whole of the stonework must be washed down and pointed. This should never be done in freezing weather, and if done in extremely hot weather there will be danger of the mortar drying too quickly. For ordinary stonework, Portland cement mixed with an equal quantity of sand, and enough water to make a stiff mortar, makes a good pointing mortar; but for limestone, marble, or any stone which will be stained by cement, lime mortar, Lafarge, or other non-staining cement must be used. If the joints are not already clean, they must be raked out to the depth of an inch and moistened, and the pointing mortar applied with a small pointing trowel, and then rubbed in smooth with a jointing tool. Either a concave, flush, or projecting joint may be made, but the concave joint is more durable than the others. The washing down of the stonework will be done at the same time as the pointing, and should be done with dilute muriatic acid, using a stiff scrubbing brush. Wire brushes are sometimes used to clean down marble and granite work. The trade of pointing is in some localities made a distinct branch of building trade, and in others the work is done by the mason.

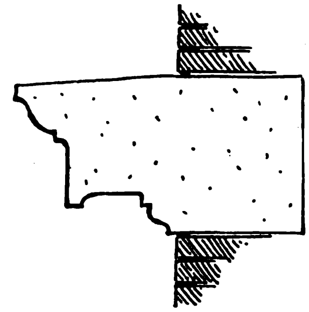
Fig. 153. Drip of Cornice Stone.

When possible, a professional "pointer" should be obtained, as he will usually have better appliances, ready for immediate use, than will the mason, whose use for them will naturally be occasional.

ROOFING AND METAL WORK.

With the completion of the exterior masonry of a building will come, in most cases, the covering in, as practically nothing further than the rough work of flooring can be done inside until the work is protected from the weather by a roof.

For the roof covering, a variety of materials may be used, common among which may be mentioned tin, copper, slate, tiles, and for flat roofs, tar and gravel composition, besides many patented preparations of paper and tar which may be used for temporary roofs.

Tin Roofs. The cheapest, and at the same time the least satisfactory of permanent roofing materials is probably tin. This may be used on steep roofs or on comparatively flat roofs, the least inclination advisable being $\frac{5}{8}$ inch to the foot. The boarding under a tin roof should be smoothly matched and covered with dry sheathing paper, and any holes in the boarding should be filled up. The sheets of tin for a flat roof are prepared by turning the edges over so as to lock with the edge of the next sheet as shown at A, Fig. 154, and they should be painted on the under side and allowed to dry before laying. The usual method of laying is to run the sheets in courses across the roof, each course being nailed at the top with short wire nails under the lap of the tin. This method of fastening should not be permitted in a roof of any extent, as the rigid nailing of each sheet will give the roof a wavy appearance when the metal expands, and the wrenching of the tin will often draw out the nails or tear the tin from the heads. When this occurs, the great mass of tin will rattle against the roof, besides being exposed to the danger of leaking. The proper way to secure the tin is by the use of strips of tin called cleats, cut about $1\frac{1}{2} \times 4$ inches. These cleats should be locked over the turned edge of the sheet and nailed to the roof, being concealed by the next sheet added. These cleats should be used about every fourteen inches along the upper edge and the side of the sheet of tin, and they will allow the roof to expand without drawing the nails or destroying the tin.

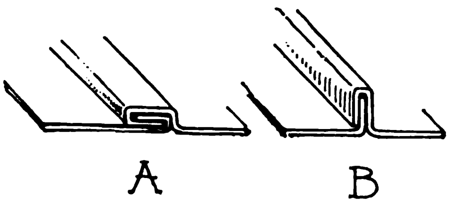

Fig. 154. Seams in Tin Roof.

When the roof has been covered, the seams are all pounded down and carefully soldered, making a continuous covering.

Against chimneys, dormers, or other openings in the roof, the tin should be turned up at least four inches to be capped by vertical flashings of lead or zinc, with gable ends carried out and tacked over the edge of the mouldings and finish. Connections should be made with metal gutters and finish by locking and soldering.

For large and steep roofs of tin, greater allowance must be made for the expansion, and this is done by means of standing seams, B, which are formed by locking together vertically the sloping seams of the roof, the horizontal seams being flat. To do this the sheets of tin are locked and soldered together into strips running up the roof, and these strips are turned up and locked together without soldering, held in place by cleats. When finished, the seam should be about an inch in height.

Standing seams are often used for effect, and a still stronger appearance may be given by ribs of wood over which the tin is locked. The tinning of a roof should be carefully watched to see that tin of the required quality is used, that the cleats are put in as described, and that acid is not used in soldering. Only resin should be allowed as a flux for soldering, as acid, which is more easily used, will injure the tin. The standard sizes of roofing plates are 14 × 20 inches and 20 × 28 inches; and they are made in two thicknesses marked I C and I X, the former weighing 8 oz. to the square foot and the latter ten ounces. The lighter brand is more extensively used, but for first-class work and flashings, nothing but I X tin should be used. Imperfect sheets, called "wasters," are put upon the market, and are packed in boxes marked I C W or I X W according to the thickness, so that where perfect plates, called "prime," are called for, the superintendent should reject any boxes marked "W." The best grades of tin are now sold with the name of the brand and the weight stamped on every sheet, and this should be noted for first-class work. It is worth remembering that the smaller sheets will make a stronger and better roof than the larger, and for a steep roof with standing seams the sheets should be laid with the narrow way for the width between the sloping seams, as this gives more chance for expansion. Tin roofs should not be painted until the rain has had a chance to wash the tin clean of grease, and all traces of resin should be removed.

Tin roofs, while under construction, should be kept clean, and rubbish never be allowed to collect, as nails and other hard substances are liable to cause perforations of the tin if stepped on by careless workmen. If tin is used for covering of a fireproof roof, the top filling should be of porous terra cotta which will receive the nails, and an even surface should be secured by smoothly plastering the surface of the terra cotta with hard cement. Steep fireproof roofs are often made by using hollow terra cotta tiles between T-irons, which may be treated in the same way.

Copper Roofing. The methods of laying copper roofing differ very little from those described for tin, except that the sheets of copper are much larger and therefore lend themselves more easily to moulded forms such as ridge rolls, hips, finials, etc. Copper roofing is often "crimped," that is, the surface is covered by fine corrugations which present a softer and more even appearance than the plain metal, and conceal the wavy appearance which plain sheets will acquire.

Slate Roofing. On roofs which pitch more than five inches to the foot, slates may be used. In this case the boarding should be matched and covered with tarred paper. On this surface the slates are laid in layers beginning at the eaves with a double course, and working upwards to the ridge. The gauging of the courses is determined by the " head cover," that is, the distance which the top of the slate is overlapped by the second slate above. (Fig. 155.) This lap should not be less than three inches.

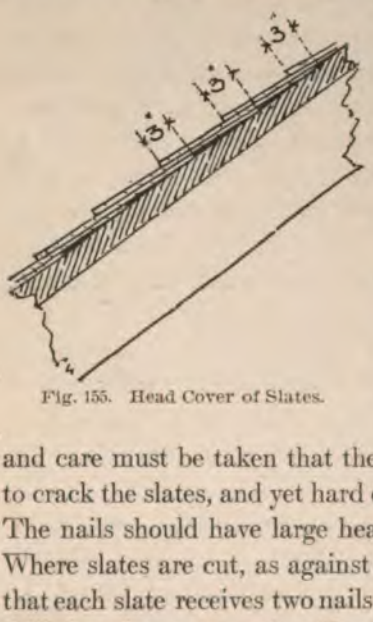

Fig. 155. Head Cover of Slates.

The usual sizes of slates are eight by sixteen and ten by twenty inches, and they run about $\frac{3}{16}$ to $\frac{1}{4}$-inch in thickness. Slates should be put on with tinned, galvanized, or copper nails, two to each slate, and care must be taken that the nails are not driven in hard enough to crack the slates, and yet hard enough to prevent them from rattling. The nails should have large heads and be 3-penny or 4-penny nails. Where slates are cut, as against hips or valleys, care should be taken that each slate receives two nails. For thick slates the holes should be drilled and countersunk. For first-class work the slates, for a distance of two feet each side of valleys and above gutters, should be "rendered," *i.e.*, bedded in elastic cement, and the same precaution taken for a foot in width against hips, ridges and all vertical parts. If slating is required for very flat slopes, the whole should be laid in cement.

Flashings. Valleys in slate roofs should be open valleys of metal at least eighteen inches wide, often laid, like a tin roof, with the end joints locked and soldered and the edges securely nailed to the roof boarding. Tin, zinc, or copper may be used, but copper is to be preferred for valleys, as well as for all flashings. Where the slope of the roof changes or where dormers, chimneys, or other vertical parts cut the roof, wide aprons of metal should be set and turned up against the rising wall to be covered over by the wall covering, or with lead counter-flashings built into the brickwork. Gables are finished by continuous metal members, run at least eight inches under the slates, and tacked over the edge of the wooden finish, or cemented into grooves cut in stone copings, called "reglets."

A good practice is to cap all flashings; that is, the metal which runs under the slates is simply turned up against the wall, and a separate piece of metal is wedged and cemented into the reglet and turned down over the other flashing to within half an inch of the roof, allowing free movement to each, which will be necessary on account of expansion and shrinkage. For the same reason it is much better to form the valleys and hips of sheets which are laid in with each course, lapping, and not locked and soldered.

Slates are sometimes laid on strips of wood or battens without boarding, but do not make so tight a roof; for fireproof roofs, however, it has been common to secure the slates to small T bars by bolts and then plaster the under side, but a better way is to lay porous terra cotta blocks between the irons to which the slates may be nailed or cemented. A method of slating which may be employed where absolute tightness is not required is called *half-slating*, and consists in leaving a space between the sloping edges of each slate, not exceeding half the width of the slate, as shown in Fig. 156.

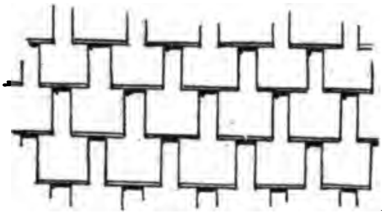
Fig. 156. Half-Slating.

In appearance, good slates should have an even color without spots, and present a hard straight grain, which shines in certain lights with a metallic, silken luster. They should be square and true, and free from warped or nicked edges, and neither too brittle or too soft.

Tiles. The use of tiles for roofing, although by no means a modern practice, has of late years become more general in this country. Tiles are made in a variety of shapes, the general principle, in all cases, being that of a slab of baked clay, moulded with an interlocking roll or rim. Tiles are laid on battens or on boarding, as described for slates; the difference being, that instead of a double lap for tightness, the tightness of tiling depends upon the fitting of the tiles into each other. Some of the modern forms of tiles are shown in Fig. 157. With tiles should be used copper or zinc for valleys and flashings, but ridges and hips are generally formed by tiles of special patterns. Plain tiles have long been used in England and are in most cases found to be in as good condition as when new. Tiles may be used on roofs which have a pitch of more than 22½ degrees, but will need a free use of elastic cement, especially in valleys, hips, and ridges. In appearance, tiles should be of even color, free from fire checks, but well burned and non-absorbent, of uniform size and without blisters, cracks or warped surfaces.

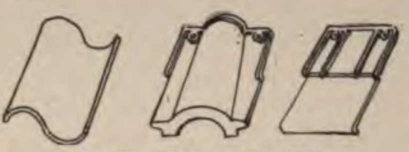

Fig. 157. Shapes of Roof Tiles.

Composition Roofing. For roofs of a pitch of ¾ inch to the foot or less, a composition roofing, made of several thicknesses of paper coated with tar, and covered with gravel on top, may be used to advantage. The mode of constructing a composition roof will be to first cover the boarding, or, in case a fireproof roof, the smooth top of the concrete with dry resin-sized felt with a lap of two inches, tacked only often enough to hold it in place. Over this are laid three full thicknesses of tarred felt, each sheet lapping two-thirds of its width over the preceding one, and the whole covered with a uniform coat of pitch mopped on. Upon this coating, two layers of tarred felt are tacked, each lapped about twenty-two inches, and the whole mopped over and a thick coat of pitch flowed on. As the durability of the roof depends upon the paper, only the best should be used, and the pitch should not be so hot that it will destroy the life of the paper. Upon the final coat of pitch is spread immediately a coat of clean white gravel, completely covering the whole, as a protection. This composition of tar and gravel makes a very good roof, but is suitable only for roofs up to a grade of three-quarters inch to a foot.

If much steeper, the heavy coat of tar will run in hot weather, and settling down, will gradually fill the gutters.

A composition of pulverized slate and asphalt, applied in layers with felting, has been placed upon the market, and is more adaptable to various pitches than tar and gravel.

The same precautions regarding the flashing of vulnerable parts will be needed in the laying of composition roofs that we have noted for slates or tiles, except in the case of the Plastic Slate roofing; here the composition itself is of such a nature that it may be applied with a trowel directly to the walls or copings against which the finish is made, and being of an elastic and adhesive nature, no great amount of metal flashing is needed.

Inspection. The supervision of roofing work of all kinds deserves the closest attention. Nothing is more unsatisfactory than to find leaks in the roof of a new building, and the time spent in securing a first-class job will be well spent. Slates and tiles are easily broken, and unless discovered and brought to notice at once, will probably be overlooked by the contractor. Composition roofs are easily slighted, and when finished give little indication of defects.

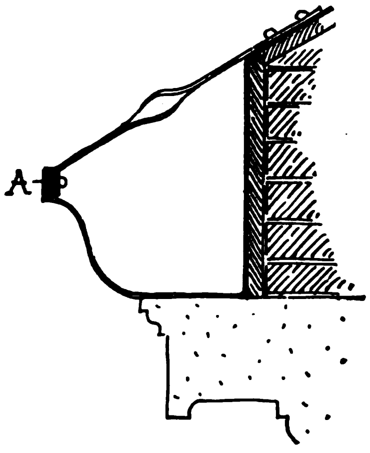

Fig. 158. Copper Gutter.

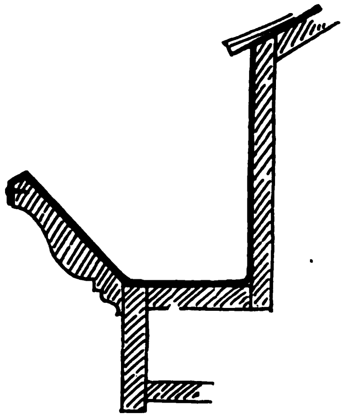

Fig. 159. Lined Gutter.

The only safeguard is constant watchfulness, which is well repaid if the roofs prove satisfactory.

Gutters and Conductors. The best material for metal conductors is copper, but galvanized iron and tin are used to some extent.

The usual form of a copper gutter is shown in Fig. 158, but it is often necessary that the face should be formed of mouldings to match or form part of a stone or wooden cornice. In this case, the gutter is formed behind the finished moulding. (Fig. 159.) The gutter shown in Fig. 158 is made of sheet copper, turned over an iron bar A, and moulded to form the trough, and made wide enough to run well up on the roof boarding, under the slates or other roof covering. Bars of copper or galvanized iron are bolted to the outer bar, and nailed and soldered to the roof. These bars should be given a short twist, as shown, so that the wash of the roof will drip off into the gutter, and not follow the strap down and soil the face of the gutter. In the case of the lined gutter, Fig. 159, the outer edge of the metal is tacked to the wood or tucked under an iron bar previously secured.

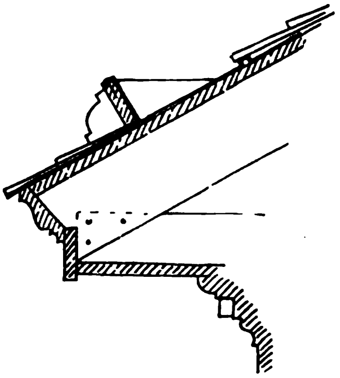
Fig. 160. Standing Gutter on Roof.

Standing gutters (Fig. 160) are sometimes used where they will not be objectionable by reason of holding back the snow, but are often a source of trouble.

In a great many cases of city building, especially with flat roofs, it is necessary or convenient that the outer walls shall be carried up as a parapet, and the roof water taken care of inside of the building. In this case a "cant-board" is used, shown in Fig. 161. This consists of a board surface set in the angle of roof and wall, and graded to the desired outlets where conductors are placed inside of the wall.

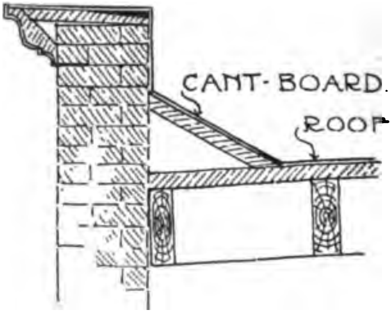

Fig. 161. Cant-Board behind Parapet.

Conductors. In the case of the inside conductors above referred to, cast iron soil pipes may be used; and these, if carried down in a brick wall, should, if ssible, be run in interior walls, and at any rate with not less an eight inches of wall between them and the outside air.

The recess is often packed with some non-conducting material. Outside metal conductors are made of tin, zinc, galvanized iron, or copper, the latter being the most desirable and also most expensive. Metal conductors should be made in some form which will permit expansion in case they should become frozen solid. A corrugated round pipe or an octagonal or square pipe is to be preferred. Conductors are usually given an ornamental top of large or small proportions according to situation.

The connection between the conductor and the gutter is usually made by a bent piece of pipe, sometimes a continuation of the conductor, and often a piece of lead pipe, shown in Fig. 162, called a gooseneck. The opening from the gutter to the conductor should be protected by a strainer to prevent leaves, chips, or other substances from choking up the pipe, and the lower end, if connected with a drain, should be properly trapped.

The superintendence of gutters and conductors should cover the construction of the trough, if of wood to be lined, to see that it pitches in the right direction and to the required points. The weight of the metal should be examined, and the manner of securing both gutters and conductors be carefully noted. Tin or iron surfaces which are concealed should be well painted, and all soldering well and faithfully done. The ends and backs of metal gutters must be examined to see that there is a sufficient width of metal to turn up against the wall, or to lie up on the roof, eight to ten inches being as little as it will be safe to allow. All rubbish in the gutters must be removed, and all connections left tight and free from obstructions.

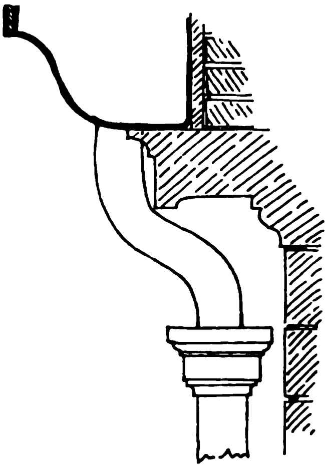
Fig. 162. Gooseneck.

Galvanized Iron Work. The use of galvanized iron for exterior moulded work and bay windows has of late years become an important factor in building construction. Especially is this true of modern fireproof buildings where it is desirable to use no wood in the exterior finish. Belts, cornices, pilasters, door and window finish, and, in fact, all the trimmings of a building, which in former times would have been made of stone or wood, are now, to a great extent, made of galvanized iron or, if not too costly, of copper. The structural treatment of galvanized iron and copper being about the same, it will be necessary to our purpose only to treat of the former, remembering that for large surfaces galvanized iron is the stouter material.

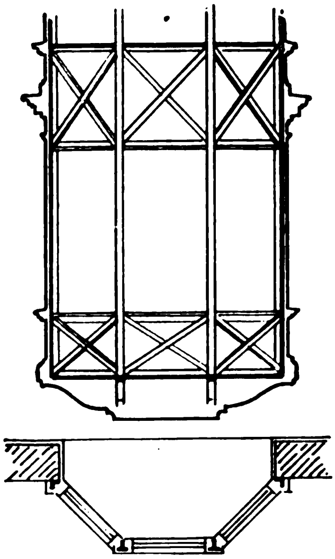
Fig. 163. Framing of Metal Bay Window.

Bay Windows. Perhaps the greatest use of galvanized iron at present is found in the construction of bay windows. In this construction the essentials are lightness and strength, so that it is usual to construct a light framework of steel, upon which the metal finish is secured, as in Fig. 163. Cornices are run on steel or iron brackets secured to the brick wall or the steel frame, as may be found most available. These brackets are shaped to conform roughly to the outline of the cornice, and it is allowable to insert a reasonable amount of boarding to form a base for any broad washes of metal, as boarding thus placed, outside of the walls, and completely encased by metal, is not in any danger from fire. For heavy projecting cornices, the brackets should be made of steel angle irons securely built into the wall, or bolted to it, or to the steel skeleton.

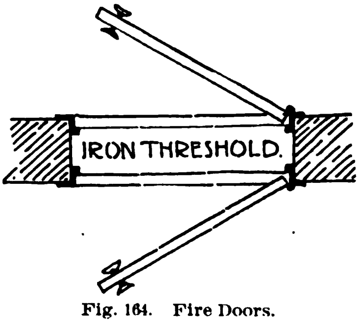

Fig. 164. Fire Doors.

Tinned Doors and Shutters. Another use to which tin is frequently put is the making of metal-covered doors for the fire protection of exposed windows and other openings. Many city laws and insurance rules require that all windows within thirty feet of a source of danger from fire shall be protected by metal-covered shutters of some kind, and a wooden shutter completely encased in tin has been found to be an effective protection. For protecting openings in party or division walls, the same kind of doors are used, one on each side of the wall, leaving an air space between of about the thickness of the wall, as in Fig. 164, and these doors are usually required to be set in rebated frames, and hung by various automatic devices of weights and fusible members, so that they will close at once if attacked by fire.

The best construction of these doors consists of a frame made up of pine 1¾ inches in thickness with flush panels, covered with tin tacked on as described for roofing, but for shutters and small doors, two thicknesses of ⅞-inch pine, nailed together and crossing each other, are used. As much care is necessary to preserve a tight interior for outdoor shutters as for a roof, as a small leak will soon rot out the pine core. The joints are all made by locking and tacking the tin, and no solder can be used, as the heat of a fire would melt it at once.

Skylights. Another use of metal for exterior work is found in the framework of skylights. These, if large, are made up of light steel angles or T-irons, and covered with sheet metal, sometimes with a lining in parts of terra-cotta blocks. If of ordinary size they will be formed up of heavy sheet metal, usually galvanized iron or copper, and in a variety of designs suited to various uses. The two principal forms of skylight are the hipped skylight, Fig. 165, and the gabled skylight, Fig. 166. All skylights should be provided with a ventilator of some sort and often a greater amount of circulation of air is obtained by building a vertical wall containing sashes or louvre blinds.

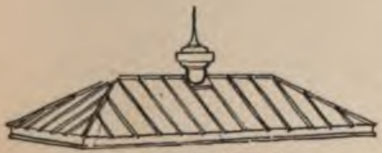

Fig. 165. Hip Skylight.

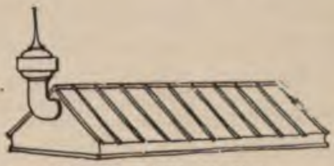

Fig. 166. Gable Skylight.

Of construction similar to large skylights but without the glazing or louvres in the walls, are roof houses; which must often be constructed to give access to roofs or to contain machinery. These, if above forty feet from the sidewalk, will be required by many cities to be of fireproof construction and are usually made of] -irons with a terra-cotta filling, and covered with sheet metal. (Fig. 167.) A precaution which must be taken in regard to the construction is to be sure that the T-irons are set with their flange inside or on the opposite side from the metal covering, or the pounding down of the seams of the metal will be likely to start the terra cotta out of place. On account of this pounding down of the seams, it is often better that the blocks should be of solid terra cotta and not hollow tiles. The connection between these houses and the main roof must be taken care of as described for roof and wall flashings, due allowance always being made for expansion of the metals. In this connection, it may be well to note that zinc for flashings should never be used where it will come in contact with iron, lead, or copper, as this contact will produce voltaic action which will finally destroy the zinc.

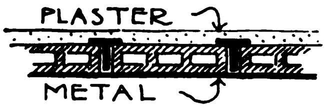

Fig. 167. Hollow-tile Wall.

FRAMING AND FLOORING.

Frame. The exterior wood framing of city buildings will in most cases be confined to roofs, since no exterior walls within the building limits of modern cities are allowed to be constructed of wood. Wooden roofs covered with slates or other fire-resisting materials are allowed, however, in many cities, up to a certain height above the sidewalk. The only difference which we shall find in this wooden construction, from the suburban house considered in Part I. will be, that usually the spaces to be covered are larger and the roofs must be consequently of heavier timber.

Floors. The same thing will be true of floors, and, from the variety of uses to which the buildings will be put, from comparatively light buildings to heavy stores or warehouses, a great range of floor construction will be required. For brick dwellings, the floor construction will differ little from the wooden house already described, the principal difference being the greater spans, and consequently heavier timbers, and also the fact that the outside bearings are taken by the brick walls instead of wooden girts. The joists in this case should run onto the wall at least four inches and should be bevelled at the end, so that, in case of fire, the floors may fall without destroying the wall. (Fig. 168.) The joists must be anchored to the walls about every five feet with iron anchors secured to the joist at the side, and low down, to allow the joist to fall out if burned. These ties should be continued across the building by tying the inner ends of the joists together and putting an anchor in the opposite wall, in as nearly a direct line across the house as possible. All large timbers, such as girders, should have anchors and should rest on cast-iron wall plates. Partitions should have a stud set close against the brick wall and bolted to it, and all large openings, such as stair wells or skylights, should have headers hung to the trimmers by stirrup-irons or patent hangers, shown in Fig. 169.

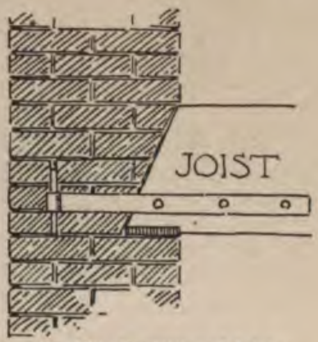

Fig. 168. Bevelling of Joists.

If there are openings in the brick walls which come so near to the bottom of the joists that an arch cannot be turned, a header should be cut in or a steel beam inserted in the wall. Joists are sometimes hung to the walls by hangers, and do not run into the wall at all; but while this preserves the full strength of the wall, it does not make so good a tie and is not generally done. The wall plate of a brick dwelling will usually be made of a plank the thickness of the wall, and secured by ¾-inch bolts which are built into the wall, as in Fig. 170. These bolts should run at least twenty inches down into the wall, and have a large washer plate at their lower end. When the wall has been brought to the required height, the plate is bored with holes to fit the bolts, and a nut and washer screwed on. Over the plate the rafters are notched, and the roof constructed as for a wooden house.

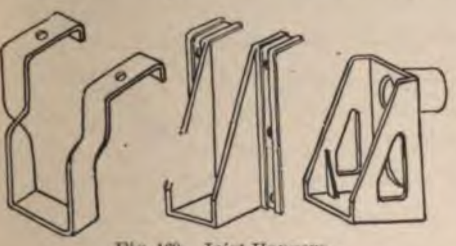

Fig. 169. Joist Hangers.

Store and Office Floors. In the construction of stores, warehouses, or office buildings, with wooden floors, the use of partitions for carrying the floor should be avoided, and columns and girders substituted. The reason for this is that, under heavy loads, the studding will often spring enough to crack the plastering, and besides, the occupancy of this class of buildings by different tenants will require numerous changes in the partitions from time to time. The large girders and posts also offer greater resistance to the action of fire, and permit of fewer concealed spaces. Many city laws require the use of brick walls, trusses, or columns and girders for support, if floor spans exceed thirty feet, and this is a good rule to observe.

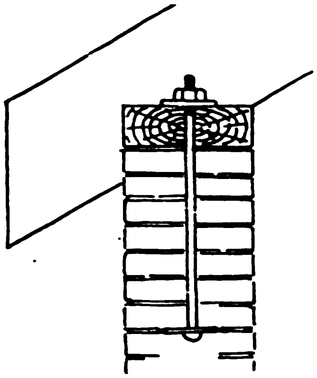
Fig. 170. Plate Bolt.

In establishing a line of columns and girders, the columns should be spaced about twelve or fourteen feet apart for wooden girders, but can be brought up to twenty-five feet for the span of steel girders. If solid wooden posts are used, they will last better if bored from end to end through the center with a hole about an inch and a half, with a half-inch hole bored into the center at the top and bottom. This allows a circulation of air through the center of the post, and guards against dry rot, especially if the post is not thoroughly dry when set. This central boring should be done from *one end*, and, if it comes more than an inch out of center at either end, it will weaken the post and should be cause for rejection.

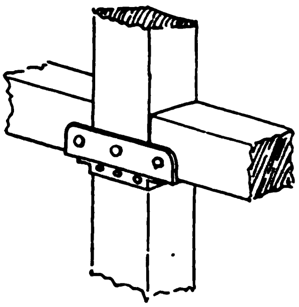
Fig. 171. Steel Post Cap.

All wooden posts carrying girders and posts above, should have an iron cap with side plates to receive the girders, Fig. 171, allowing the post above to be supported directly by the post below, and not to stand on the girder. This must be done for two reasons. One reason is, if the girder ran over the top of the post and the post above were set upon it, the natural shrinkage of the girders would be multiplied by each succeeding floor, and in a building of four or five stories, this might amount to two or three inches, so that the upper floor beams at their inner end would be that much lower than the outer ends which are supported by the rigid masonry. Another reason is, that the crushing strength of the girder in its longitudinal position is not so great as the post standing on end, and it might be unable to support the accumulated weight of several stories. This support was formerly obtained entirely by the use of cast-iron pintles, Fig. 172, which are cast with top and bottom plates to fit the posts, the weight being transmitted by the cross-shaped metal. This is an effective method, but has been superseded by the more modern steel caps. The bearing of the girders should be at least five inches on either end, and a box hanger of some kind should be used to support the wall end of the girder, as shown in Fig. 173.

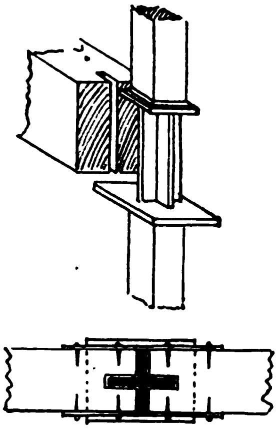

Fig. 172. Cast-iron Pintle.

Iron and Steel Supports. For large spans and heavy weights it will be often necessary to use iron or steel columns with wooden girders. If cast-iron columns are used, they should not be made with a shell less than three-quarters of an inch thick. This is necessary on account of the danger of an unequal thickness in the shell of the column. To obtain the hollow column, the casting must be made about a "core," and although this core is accurately centered, there is danger of its being displaced by the pouring in of the molten iron, as, being of a lighter composition, it will have a tendency to "float." This may result in an added thickness to one side of the shell of the column and a corresponding lack of metal on the opposite side. To guard against this defect, cast-iron columns should always be tested by boring a small hole on opposite sides, and if more than one-fourth of the thickness of shell is wanting in any column it should be rejected. The outer surface of cast iron should

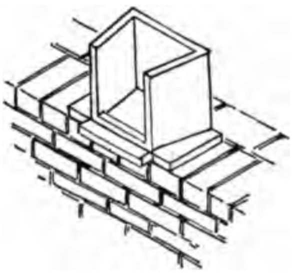

Fig. 173. Box Anchor on Wall.

be smooth and clean, with sharp angles; and all projections, such as lugs, caps, or bases, should be closely examined to detect the presence of cracks which may occur at these points.

Cap and Base. The top and bottom of all cast-iron columns should be turned off in a lathe to insure a bearing at right angles to the axis, and plates should be used to increase the bearing. These plates are cast with a ring or with projections to hold the column in place against movement, and they should be planed to a perfectly even bearing. The cap must never be spread out as a casting, Fig. 174, but should carry up the line of the column itself, all ornamentation requiring a great projection being cast separately and fastened on, as in Fig. 175. This allows the shaft of the column to run straight up to bear the weight of the column above, while the girder is borne by the projections cast upon the column. The distance from the cap to the top of the column should be about four inches greater than the depth of the girder to allow room for bolting the columns together.

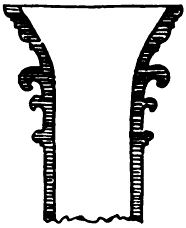

Fig. 174. Improper Casting of Column.

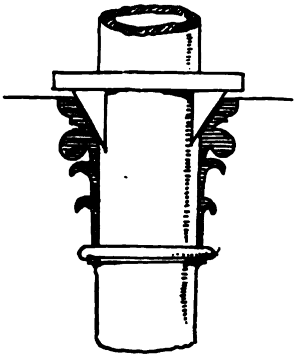

Fig. 175. Proper Application of Ornament.

With a wooden girder, the ends of the timber must be cut out to fit the diameter of the column (Fig. 176), and the girders must be tied across the cap by stout straps on each side. If steel beams are used, they can be tapped to the column plate or strapped together around the column.

Pipe Columns. Heavy wrought-iron pipe is often used for columns, a cap and base being sometimes cast and screwed on by a thread; and a patented column formed by filling the pipe with cement, may be obtained ready fitted with cap and base.

Steel Columns and Girders. Where the spacing of columns is required to be increased beyond the safe bearing of wooden girders, steel girders may be used. These usually consist of one or more steel I-beams, and they may be used with cast-iron columns or with steel columns. With cast-iron columns, the same methods will suffice as in the use of wooden girders, but with the use of steel columns a new method of construction arises, which it will be better to consider later in connection with steel framing. It may be properly said here, however, that the use of steel girders and steel columns, even if the floor timbers are of wood, is to be recommended for high buildings or for buildings which are subjected to the jar of machinery; the reason for this being in the greater rigidity which is possible in the girder and column connections, and the greater ease with which this construction can be braced.

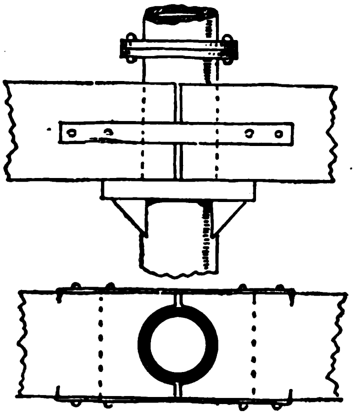
Fig. 176. Seating of Girder on Column.

Floor Beams. The use of wood or steel for girders will require different methods of construction. If wooden girders are used they may be set wholly or partially below the floor timbers, or flush with them. If there are no objections to dropping the girder below, this is the simplest and strongest construction. In this case, the floor beams should be sized down on the girders to maintain a per-

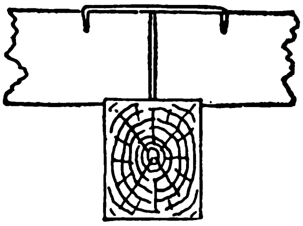
Fig. 177. Iron Dog.

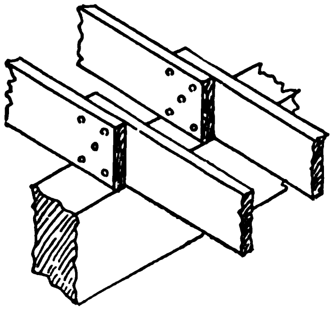
Fig. 178. Spiking of Joists.

fectly level floor line, and a full bearing should be obtained for each timber. Where the girders are large the timbers may be brought to butt against each other upon the girder; and they should be secured end to end by iron dogs which turn down into each timber. (Fig. 177.) For small girders and light timbers, it will be better to let the timbers lap close and be spiked to each other, as in Fig. 178.

When the girders are near together, and the timbers long enough to span two divisions, a rigid floor may be obtained by "breaking joints" with the floor timbers every five or six feet.

Flush Framing. If the girder is to be framed flush with the timbers, the use of stirrup irons or patent hangers is recommended, as preserving the full strength of the girder. In this case the timbers should be brought as nearly opposite as possible, and iron dogs long enough to reach over the girder and drive down into opposite timbers should be used. (Fig. 179.)

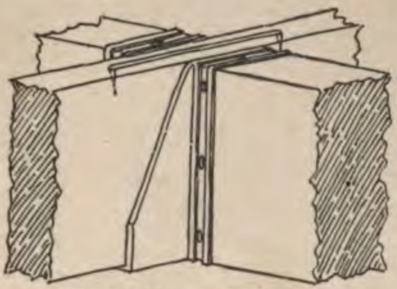
Fig. 179. Hanging of Joists.

If the girder is deeper than the floor timbers it may be set flush on top, and smaller pieces of hard pine or an angle iron may be bolted to the lower part to receive the floor timbers, as shown in Fig. 180.

Crowning. All floor timbers having a span of more than sixteen feet should be crowned, that is, the top of the joist is cut to the shape of an arc of a circle, having a rise of one-quarter inch to every sixteen feet of span. This is necessary to allow for the ordinary sag of the timber, so that a level floor may result.

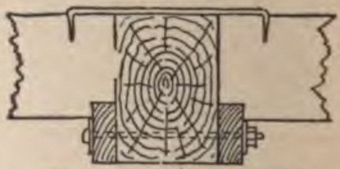
Fig. 180. Wooden Girder and Joists.

Steel Girders. With the use of steel girders new considerations will arise. If a single beam is set entirely below the floor timbers, it will give a better bearing if the timbers lap and spike to each other. With two or more beams, the timbers may be brought end to end as on the heavy wooden girder. If the steel girder is set flush with the beams, they may be cut so as to run into the trough formed by the flanges of the beam, but should be supported by stirrup-irons or hangers, Fig. 181, as the sloping flange of the steel beam does not afford a good bearing. If the steel beam is deeper than the floor timbers, a common method is to bolt a timber to each side of the beam for a bearing; and of course an angle bar can be used in the same manner. (Fig. 182.) In any case, the floor beam should be fastened so that there is no danger of slipping out of the hanger. Most of the patent hangers have a lug, or bolt, to secure the timber in place, and where timbers come opposite, common iron dogs turning down into each timber may be used.

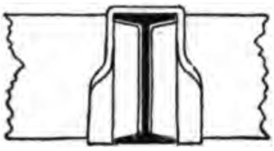
Fig. 181. Stirrup Iron and Steel Girder.

Slow Burning and Mill Construction. The use of the methods of heavy timbering just described, with floors of matched or splined plank, and with no wood partitions or furrings enclosing hollow spaces, constitutes what is generally termed *slow-burning construction.* To obtain the best results from this method of construction, wooden girders should always be set flush with the floor timbers on top, as the dropped girder with the space above will permit flames to lap around the timber and it will be more quickly consumed than if it is flush with the rest of the floor beams. Greater protection is obtained by protecting the wood with plaster on metal laths, leaving no air spaces between the plaster and the wood.

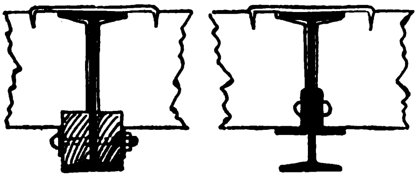
Fig. 182. Connection of Wooden Joists and Steel Girder.

Mill Construction, as its name denotes, should properly belong to the particular methods of construction which have been devised for resistance of fire, and the sustaining of the loads and shocks of machinery, to which manufacturing buildings are particularly subjected. This requires primarily the disposition of the timber and plank in solid masses exposing the least number of corners to the action of fire, of separating the floors by fireproof stops, and automatic arrangements of closing hatchways or elevator openings, and of enclosing stairways in incombustible partitions.

The typical construction employed for the mills of New England, and the only form acceptable to the insurance companies of that section, consists of posts at least 10 × 10 inches, spaced about eight feet apart in the length of the mill and twenty-four or twenty-five feet across. Instead of a line of girders running lengthwise over the line of posts, the floor beams are laid across the mill on the tops of the posts. These beams are usually 12 × 14 inches, or two pieces of 6 × 14 inches, bolted together with an air space between. The wall end of these timbers should rest on iron plates and the ends be bevelled off and secured only at the bottom, so that they may fall out easily if burned, and not pull down the wall. (Fig. 183.) These timbers are supported by iron post caps or pintles, as already described. The flooring consists of a layer of three-inch planks, not more than ten inches wide, splined together and blind-nailed; and it should be long enough to span two spaces, breaking joints every four or five feet. All of this construction is usually of Georgia pine.

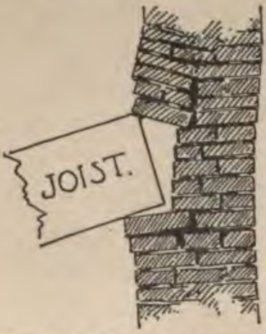

Fig. 183. Effect of not bevelling ends of Joists.

The upper floor is generally made of hardwood such as maple or birch, and this is laid with square edges over two or three thicknesses of paper, each layer being mopped with tar, asphalt, or similar material; or sometimes a layer of plaster is spread between the upper and under floors.

This construction may be adapted to the use of mercantile or office buildings, but the general requirements of this class of buildings will not admit of the posts occurring so often as every eight feet. This necessitates the use of a girder and intermediate beams. If these beams are spaced four or five feet apart, it will permit the use of two-inch plank which may be tongued instead of splined. With this increased spacing of the posts, it will be necessary to use iron or steel posts for a building four or more stories in height; and if the posts are more than fourteen feet apart, it will be cheaper and better to use steel beams for girders. In this case all weight-bearing metal must be protected by at least an inch of plaster or other fireproof material.

Partitions. Where slow burning or mill construction is used for the floors of a building, the partitions should be made of solid plank plastered on both sides on metal lathing, or else of light steel framing with metal lath, and plaster.

Roofs. The same methods of framing may be employed for the roofs as foı the floors, but lighter timbers can be used, set to the required pitch, with a tar and gravel or metal roof. Steep pitched roofs may also be constructed in the same way, trussing the timbers if the span requires it.

Supervision. The supervision of the framing of floors of brick buildings will call for constant vigilance on the part of the superintendent, as it is not only necessary to follow closely the work of the carpenters, but the fact that the mason-work is being carried along at the same time, by a different set of workmen, will necessitate a great deal of forethought in order to bring the different parts together at the proper time.

The anchoring of floors properly, and at the proper time, will require constant attention, and the setting of plates, the building-in of bolts and hangers, and the leveling-up of floors and walls to their relative positions, will require harmonious action between the mason and the carpenter.

In heavy framing, careful watching will be necessary, to see that proper connections are made between post, girders and floor beams, and that all necessary ties, straps and bolts are set and tightened.

If trusses occur, they should be strained up tightly when built and kept tightly strained as long as there are any workmen remaining at the building, as the shrinkage of the timbers will often loosen the joints and allow sagging to occur.

Flooring. As soon as the floor timbers are in place, it is generally the custom to lay down a rough floor. This makes a platform upon which subsequent operations are carried on and also forms the foundation for the upper or finished floor. The character of this rough lining floor will depend upon the nature of the floor construction. If the floors are of slow-burning or mill construction with the beams far apart, plank must be used of varying thickness according to the spacing of the beams. For a spacing of four or five feet, 2-inch plank may be used, but from five to eight feet of space will require 3-inch plank. This planking should be matched or splined and securely nailed to every bearing, and it will add to the rigidity of the building if laid diagonally, besides giving an even surface upon which to lay the finished floor. For the under floors of dwellings or other buildings of ordinary light construction, an under floor of ⅞-inch hemlock or pine is generally used without matching. The boards should be mill-planed to an even thickness and as narrow as can be readily obtained. The under flooring should be securely nailed to every bearing, and should be laid close to the exterior walls, covering the floor surface completely with no large holes or wide crevices.

Upper Floors. The laying of upper floors should be delayed until the finish of the rooms has been completed, up to the hanging of the doors. For floors that are to be carpeted, spruce or pine is generally used, and this may be laid without matching. For floors not carpeted, hardwood flooring should be used, and the boards should be sawed into narrow widths and matched and blind-nailed.

For floors of kitchens, offices or other places where much wear will come, and where the expense of oak or other fine woods is not desirable, floors of rift Georgia pine may well be used. Birch and maple also make a good floor and have good wearing qualities. For parlors, halls, and for parquetry flooring, oak is used to a great extent, either by itself or in connection with other fancy woods. All hardwood flooring should be quarter-sawed. The usual thickness of flooring stock is ⅞-inch, but for stores, factories, or public buildings, 1⅛-inch or 1½-inch stock should be used.

Stock. Spruce and pine floorings are carried in two grades—first and second quality. First quality is free from knots, while second quality will have small and tight knots.

Hard pine flooring is rated as rift, or "quarter-sawed," first and second clear, and star. Only rift hard pine should be used for a good floor, as "slash" boards will split and sliver. Oak flooring should always be quarter-sawed, and this as well as all hard woods should be used in narrow widths, 2½ inches being as wide as should be used for first-class work. First-class flooring is usually grooved on the under side to lie close to the under floor and should be matched and blind-nailed for good work. For offices or factories, square-edged boards will wear better and admit of renewal more easily than matched flooring. Floors laid diagonally or across the under flooring will lie smoother and remain closer, than if laid the same way as the under floor. If the added stiffness is desired for mill floors, and it is not convenient to lay the floor diagonally, a degree of stiffness may be gained by laying the floor square and nailing it in diagonal rows.

Paper and Deafening. Between the upper and under floors, paper should be laid, and a deafening of plaster, quilt or mineral wood may be used. For mill or factory floors, two or three thicknesses of paper should be used, mopped with tar or asphalt.

Tiling and Mosaic. Where tiling or mosaic is used for the upper floor in wooden construction, special preparation will be needed to obtain a thick bed of concrete or bricks under the tiles. To do this the rough floor must be let down between the timbers, and supported by strips nailed to the sides of the floor beams, as shown in Fig. 184. A bed of at least 4 inches should be provided, and the beams should be cut off to a bevel on top as shown. Even then there is a tendency for the tiles or mosaic to develop a crack over the beams, and so metal lathing is often used to prevent the concrete bed from cracking. This preparation is necessary for old floors which are to be tiled, or where the tile floor covers only a portion of a new floor, but when the whole of a new floor is to be covered with tiles, and there is nothing to prevent, it will be better to set the floor timbers enough below the finished level to obtain the same result. (Fig. 185.) Narrow boards should be used laid ⅛-inch open to allow for swelling.

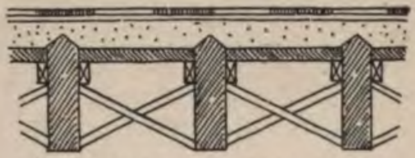
Fig. 184. Old Floor Prepared for Tiling.

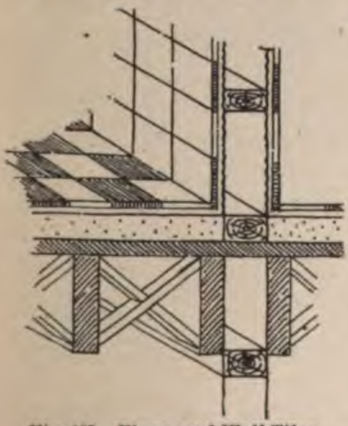
Fig. 185. Floor and Wall Tiles.

To prevent the moisture in the concrete from being absorbed too quickly by the boarding, and to guard against dripping, two thicknesses of tarred paper may be spread over the whole surface before the bed is laid, and the use of corrugated metal lathing is sometimes advisable. The preparation of wooden walls for tiling is more simple. Here it is only necessary to provide a firm and continuous sheet of plaster upon which the tiles are bedded. This may be done by cutting in between the studs, horizontal pieces two inches by the width of the studding and about a foot apart, upon which metal lathing is nailed; and a rough bed of cement mortar is spread upon this, allowing room for the proper bedding of the tiles. (Fig. 185.) Hair should be used in the cement mortar on wire lathing.

Tiling. Tiles of various patterns and materials are used to a large extent for floors and walls of bathrooms, corridors and counting rooms. For fireplaces, and walls and floors of bathrooms, where the tiles are not subjected to hard wear, a plain glazed tile makes a clean and satisfactory job, but where much wear will come, the hard, vitreous, unglazed tiles will make a better wearing surface.

The foundation for tiles should be prepared from the best Portland cement, and should be perfectly level, and allowed to thoroughly harden before the tiles are laid. The foundation for both floor and wall tiles should be thoroughly brushed, to remove all dust and other foreign substance, and then well wet before applying the cement bedding. Portland cement should be used for setting floor or wall tiles, and for grouting the floors; and the best Keene's cement for filling the joints in wall tiling. Clean sharp sand well screened should be used in equal parts with the cement for floors, and with two parts sand to one of cement for walls. The tiles must be thoroughly soaked in water before setting.

Floor tiles are set by being firmly pressed into the mortar bed and then tamped until perfectly level. When the bed is sufficiently set, the joints are grouted with pure cement and cleaned off with sawdust or fine shavings.

Wall tiles are set by two methods called "floating" and "buttering." In floating the tiles, a portion of the bed is spread on the wall, and the tile placed in position and tamped until firmly united. Buttering consists of spreading the mortar on the back of each tile, which is then placed against the prepared wall and tapped gently until it is united with the bed. When the tiles are all set, by either process, the joints are carefully washed out and filled with Keene's cement. When fixtures are to be secured to the walls, as for plumbing etc., a wood piece should be secured to the wall, flush with the rough bed, and the tiles laid over it, to be bored for the fastenings.

Floor Finish. For halls and corridors, mosaic, tile, or terrazza floors are to be preferred, but for offices, nothing is better than a wooden floor. Rift hard pine, birch, maple, or oak make good wearing floors, and when laid on sleepers securely bedded in the concrete, with no chance for the air to get beneath the floor, are in little danger of being consumed by fire. Wooden floors should be matched and tightly laid, and treated with as little oil or inflammable varnish as possible, depending upon constant care, for preservation, rather than a great amount of finishing.

Counters. For banking rooms and corporation offices, counters of greater or less extent and elaboration will be required. These are usually made of wood, but may be constructed of other materials, a wooden top being always preferred. The use of enameled bricks or tiles for the base of the counters with a wooden top makes a solid structure, while polished marble may be used of almost any degree of expense.

Grille Work. An important feature of a modern building is the grille work made of various metals and used for protection, decoration, or effect to a great extent. For exterior ornament or protection, grilles will be found principally in door or window openings, and in this application, wrought-iron grilles are generally used. Window grilles are generally set in the depth of the stone or brick jamb of the window, as in Fig. 186, but are sometimes put over the opening on the outside face of the wall. This is usual if the window is small. (Fig. 187.) The fastenings of grilles should be secure and lasting; and they should in general be set in a rim of iron with hinges and locks, so as to allow easy access for cleaning the windows. (Fig. 188).

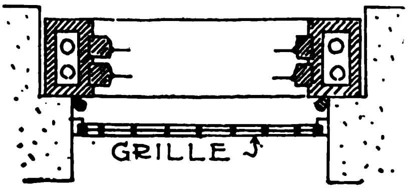

Fig. 186. Usual Position of Grille.

Door grilles are sometimes glazed on the back with plate glass, so as to form a weatherproof door having the effect of the grille, and when this is to be done, care must be taken to bed the glass carefully, as the expansion and the jar of closing are likely to crack the glass.

The interior use of grilles will be found chiefly in the protection of elevators or lifts, and the exclusion of the public from the working portions of offices and banks. Elevator grilles are generally made of wrought iron, and they should be at least 7 feet 6 inches high on the sides and carried from floor to ceiling in front of the doors of the car; and all portions within easy reach of the public, where there is danger that the hand might pass through, to be injured by the moving parts of the elevator or counterweight, should be of a fine pattern or protected by fine netting. The main support of the elevator grilles will be found in the corner posts which support the elevators, or the stairs which often enclose them on three sides, and the pattern of the grille work should be stout enough to stand rigid between these supports. Wrought-iron grille work of all kinds should be carefully inspected to see that the scrolls are well turned, that welding or riveting is neatly done, and that the whole section is tightly put together. Cast-iron patterns must be inspected for smoothness and clearness of the ornamental parts, and an even thickness of metal should be required for all similar parts.

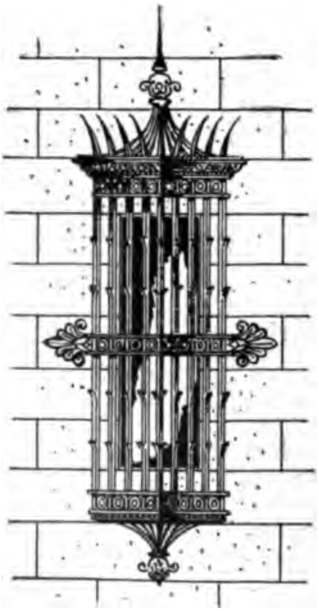
Fig. 187. Grille Outside of Window.

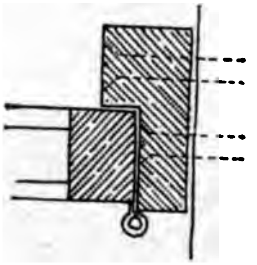
Fig. 188. Hingeing of Grille.

The counter and office grilles are often made of thin steel, bent into various patterns and riveted together, and this construction is also used for elevator cars where lightness is a valuable feature.

These grilles are finished by plating with copper, bronze, nickel, or other metal, and can be given almost any desired tone.

While these grilles do not compare in appearance with wrought-iron grilles, they are less expensive, and quickly made, and may be readily obtained of the manufacturers in a variety of stock patterns.

Fireproof Vaults. All banking and large commercial offices require a fireproof vault of some sort, for the preservation of valuable records as well as money. These vaults in a building of ordinary construction are easily made of bricks and steel beams. The vault, in principle, consists of a thick wall of bricks with proper air-space and covering, enclosing a space of greater or less extent, access to which is given by a double set of doors, separated by the width of the wall, at least, and securely fastened from without. To withstand the effect of a conflagration, the walls should be built with an inner wall of eight inches of brick; then an air space of four inches and an outer wall of at least eight inches of brick, with both walls tied together across the air space, which should be ventilated top and bottom. This gives a wall twenty inches in thickness and allows a door to be made with the outer valve in one leaf and an inner door in two parts, these parts opening in a vestibule formed in the thickness of the wall. (Fig. 189.) The top must be covered with bricks laid on iron bars or beams, and must be at least twenty inches thick to withstand the heat and the falling of beams or masonry. (Fig. 190.)

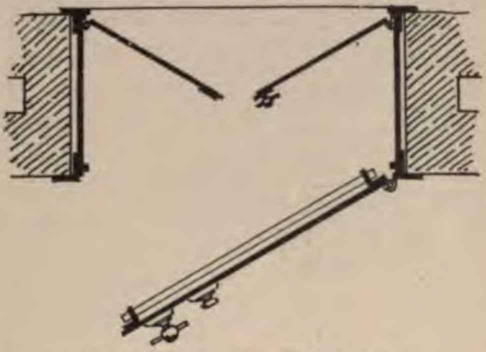

Fig. 189. Door of Fireproof Vault.

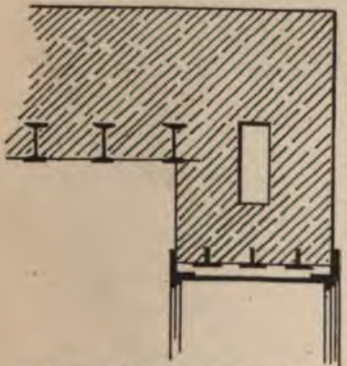

Fig. 190. Top of Fireproof Vault.

Vaults of this construction are fireproof but not burglar proof, the latter requisite being obtained by a lining of chilled steel or a separate burglar proof safe set within the brick vault. Vaults have also been made burglar proof by constructing them of concrete, in which are embedded old iron or steel bars or rods, to an extent that it would require a long time to effect an entrance of sufficient size to extract any part of the contents. Copper wires are sometimes laid in concrete at intervals of three inches or less, connected with a battery which will ring an alarm bell if the wires are tampered with.

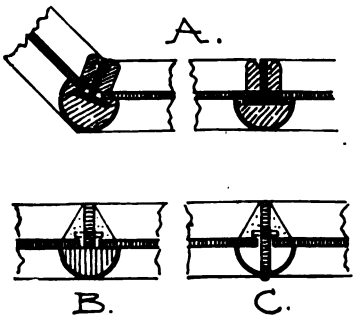

Fig. 191. Sash Bars.

Store Windows. The modern desire to expose as much plate glass as possible in store windows has led to the development of a special construction for these windows, with the object of reducing the necessary supports of the glass to a minimum. For ordinary store windows, where the lights are not more than 6 feet wide, the bars may be made of a common T-bar covered by a half round of nickel-plated brass over a wooden form, A, Fig. 191, the glass being set from the inside, and held in by pins and putty or wooden stop-beads.

Sometimes a half-round bar is screwed to a web piece of iron, and the outside painted or covered with nickeled brass, as at B, Fig. 191. Another form giving greater strength of web is shown at C.

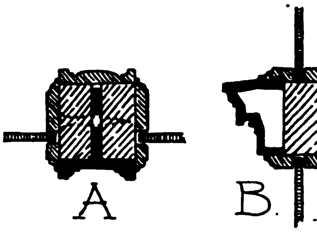

Fig. 192. Sash Bars.

For larger lights, a special construction is required, giving greater strength; and this is often done by means of a special casting exposed and ornamented on the front, but otherwise concealed in the wood finish, as at A, Fig. 192. These castings should be about 2½ inches wide by 3 inches deep, depending upon the size of the glass, and the glass may be set either from the outside or the inside, and held in place by moulded stops which may be made of metal on the outside, if desired. If transoms are used, they may be of the same section as any of the bars, or a more ornamental form may be given, as B, Fig. 192.

The top of the window will usually have the same section as the sides, and the sill will depend upon the character of the show window and whether the sash comes to the floor or not. If a bulkhead is required with cellar lights under it, a section similar to Fig. 193 is often employed. To prevent the windows from becoming frosty in cold weather, ventilating openings, through which the condensation also may drain out, are provided, and a trough to connect with these openings. Basement sashes should be provided with wooden sills fitted over a lip in the iron or concrete of sidewalk, or bedded tight if the sidewalk is of stone or brick.

The corners of store windows may be treated by adapting any form of bar to the angle, and where it is of advantage to show no bar at all, the two sheets of glass coming together at an angle may be made to support each other by clamping them together with no dividing bar. Several patented forms of connection may be used for this, as well as for the dividing bars. In setting large lights of plate glass, a backing of rubber or leather should be used in place of the usual back-puttying.

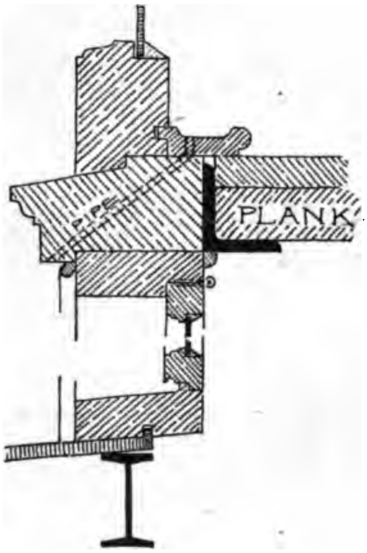

Fig. 193. Sill of Store Sash.

Mail Chutes. For the convenience of the occupants of offices above the first floor of any building, the system of mailing letters by means of a specially constructed chute connected with the mail box at the bottom, should be adopted, and location and preparation made for it during the construction. This system, which is patented, must be installed subject to the approval of the local postmaster, and all the apparatus, when erected and accepted by the Post Office department, passes under the care and control of the Government, by which the locks and boxes are authorized, The boxes are of various sizes and patterns, and are furnished by the makers of the chutes. The chutes are required to be in removable sections, exposed to view and easily accessible, and they may be run only in the public hall or corridors of a building. The chute must be made of metal with a plate glass front, clearly marked with the insignia of the department, and when installed becomes technically a part of the government mail box below.

The requirements for support of the chutes are a continuous vertical surface 10½ inches or more in width, carried from the box below to a point not less than 4 feet 6 inches above the top of the highest floor to be supplied. In front of this vertical run must be set the iron thimbles provided by the makers, 3⅝ inches by 9 inches, the whole absolutely plumb, with no bends or offsets anywhere..

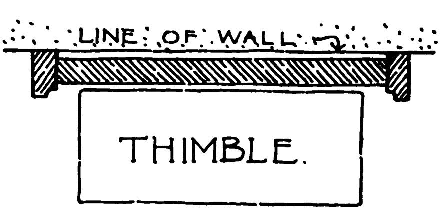

Fig. 194. Backing of Mail Chute against Wall.

For wooden buildings a flat casing of wood may be used, or marble or other costly material may be substituted wholly or in part. This construction is generally used where the chute runs against a wall, as in Fig. 194. Where the chute runs down beside an elevator grille, or in other places where a solid back would be objectionable, two "square root" angle irons are generally used and turned so as to give an even backing, Fig. 195, the thimble in all cases being the same, and the angle irons being secured to the floor beams or other rigid support.

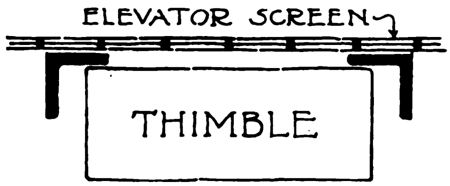

Fig. 195. Backing of Mail Chute against Grille.

This preparation may be made a part of the building contract or of the mail chute contract, but will have to be done to the satisfaction and acceptance of the makers of the chutes and of the local Post Office department.

FIREPROOF BUILDING.

The most modern feature of city building construction is the erection of the high business blocks which form the main part of the commercial districts of all cities. Here a variety of problems present themselves, more or less complicated according to the nature of site and surroundings, of size and usage.

In the first place, the value of the land which the proposed building will occupy must be considered. Real estate in the heart of our large cities attains almost fabulous value, and the first consideration which the owner will require, will be the maximum of rentable area within the walls of his building. This of itself will force us to adopt a system of construction which will permit us to erect the building with the thinnest possible walls that safety and the building laws will allow, and the same consideration of rent will force us to build as high as possible. From this tendency has arisen the modern "sky scraper," a construction consisting of a steel skeleton covered with masonry, simply as a protection for the steel, and for the contents of the building, but having no weight-bearing value of itself. The floors and walls are supported wholly by the steel frame, which is carried usually on isolated supports far below the sidewalk. This is the common form of high building and is known as skeleton construction.

Sometimes the exterior walls are made strong enough to be self supporting, the steel frame carrying only the floor loads, but in this case there is danger of unequal settlement between the frame and the enclosing walls, whereas if the whole of the load is carried by the steel frame, the footings can be proportioned so as to give equal settlements. In doing this, it is customary to use only the dead load,—*i.e.*, the weight of the building material—in establishing the proportions of the footings, for if the live load of people and merchandise were to be included, the interior footings would have a much higher percentage of live load than the exterior footings, and as the live load is not constant, it would be impossible for the building to settle uniformly. This has been proved by the present condition of existing buildings which have been erected upon a compressible soil, the tendency being for the interior footings, which are subjected only intermittently to their full live load, to settle less than the exterior footings where the dead load of the walls is constant, unless due allowance is made. Some authorities allow 25 per cent of the live load in addition to the dead load upon the footings, but difference in soil will require especial allowances. The essential point in any foundation is not to overload the soil, so as to cause excessive settlement, and to so distribute the loads that the settlement shall be uniform.

Height of Buildings. As the owner will naturally desire to obtain as many floors as possible, it will be necessary to consult, first of all, the building laws of the city in which the building is erected, to determine the height to which our building may be carried. This determined, the number of floors must be decided. As the lower floors are less likely to be subdivided than the others, they must be given a height which will be in proportion to the probable size of the rooms, so that the height of the lower stories must be added together, and the sum, with the addition of the thickness of the floors, must be taken from the whole height of the building before we can establish a unit of height for the rest of the stories.

The Building Site. While these matters are under consideration by the owner, an examination of the proposed site will be profitable, to gain necessary information in regard to party walls and the condition of adjoining property. The nature of the soil, the location of sewers and other underground works, will be factors in the proposed construction, and all data relating to these matters must be recorded and carefully preserved.

Preliminary Work. As soon as the instructions of the owner, or the recommendations of the architect, have been definitely adopted, the construction of the building will be laid out. As the problem will resolve itself into the disposition of a greater or less number of isolated points of support, instead of the ordinary continuity of walls, it will be necessary to study the construction at the same time with the laying out of the offices, in order to bring the necessary vertical supports as much out of the way as possible. Another consideration will be the thickness of the floors. As the number of floors is sure to be considerable, it will readily be seen that an excessive thickness will result in considerable loss of height; and, if the thickness of each floor can be kept down to a reasonable rate, it may be the means of obtaining a story more for rentable purposes, which is a matter worthy of consideration.

These factors, which do not enter so strongly into the problems which we have previously considered, must have careful consideration in constructing mercantile buildings of the class which we have now before us; and upon their skillful employment will depend the success of the enterprise.

In the bringing together of these elements to form a whole composition, certain external elements must be considered. Among these are *ease of access, the maximum of light, rentable area, ease of rearrangement* to suit tenants, and *the minimum of cost.* Ease of access will require that the elevators and stairs shall be placed in direct and obvious connection with the entrances and as nearly as possible at the level of the sidewalk, readily seen on entering the building or on leaving the offices to which they give access. The position of the elevators will be of more importance than the stairs, as the latter will be little used in high buildings. To obtain the best light possible it will be well to provide that the areas (which will be a necessity in a building in the interior of a block or in a wide building on a corner) shall have a general direction north and south. These areas should not be narrower than six feet and should contain windows as large and as near the ceiling as possible, and the rooms should be as nearly rectangular as may be, thus avoiding dark corners.

The structural conditions will enter more or less into the arrangement of the offices, as already suggested, and to this must be added ease of adjustment to the needs of the average tenant. The unit of size and arrangement of the offices should be such that a tenant who wants a single office may have one of average size, or a tenant who wishes, may have the whole floor, except the minimum of space necessary for toilet rooms, elevators and stairs.

The Structure. When the character of the building and the general divisions of the floor space have been established, the location and design of the columns, the kind of wall and floor construction, and the size and spacing of floor beams and girders must be determined. The location of the columns and girders will be determined by the size and shape of the floors, the position of present or future partitions, the floor loads, and other considerations which arise with different locations and uses. In general, the most economical spacing of columns and girders will vary from 14 feet to 16 feet.

The spacing of the floor beams will depend upon the system of floor construction used.

Columns. The columns used in skeleton construction are generally made up of a combination of the standard shapes of steel bars. One of the commonest forms of steel column is the Z-bar column, shown in Fig. 196. This column is made by bolting together four standard Z-bars with reinforcing plates, the bars and plates increasing in size and thickness as the loads to be supported increase. The column shown in Fig. 196 is of the type known as "closed columns" and can be used only where there is no necessity for repainting the steel, as only the outside surfaces are accessible. The open form of column, Fig. 197, is more generally used. Other forms of steel columns are formed from standard beams, Fig. 198, or from channels and angles, Fig. 199. As these columns will be required to support a heavy load in most cases, bases must be used which will distribute the weight over a surface large enough to sustain the load. This may be done by the use of a cast-iron base, Fig. 200, or a base built up of steel, Fig. 201.

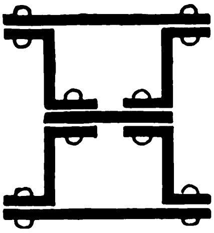
Fig. 196. Closed Z-bar Column.

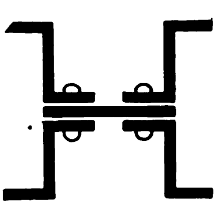
Fig. 197. Open Z-bar Column.

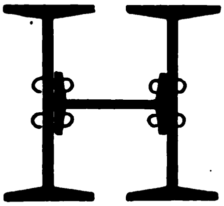
Fig. 198. Steel Beam Column.

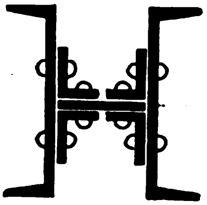
Fig. 199. Channel and Angle Column.

The selection of a particular form of column section will depend upon varying conditions, being generally determined by the amount of load and the way in which the floor beams come to the column. The shape and size desired for the finished column, the thickness and detail of enclosing piers, and the availability of certain shapes, are also factors.

Erection. To save time and labor, it is customary to run the columns in lengths of two stories each. This takes more metal, but the gain in time and labor will generally offset it. The splicing of columns must be made with a perfect bearing of the metal, so that the load is transmitted from column to column, the splice-plate giving the full strength against lateral movement. (Fig. 202.)

In this connection attention should be called to the importance of starting and maintaining the columns perfectly plumb and always in line. To do this, it is necessary that the bases should be set absolutely level, as the slightest variation at this point will increase as the work is carried to a height. For this reason bases should never be set by means of an ordinary mason's level, but an engineer's level should be employed to insure accuracy. If this is done, and the end sections of the columns are milled off properly, there is no reason why perfectly plumb work should not be maintained, permitting the spliced joints of the columns to bear perfectly upon each other without the use of thin "shims," which should not be allowed.

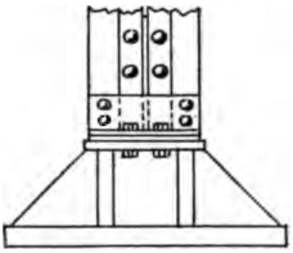

Fig. 200. Cast base for Steel Columns.

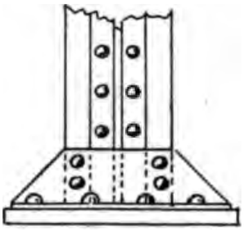

Fig. 201. Steel base for Steel Columns.

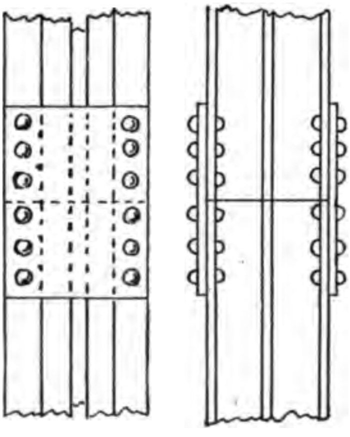

Fig. 202. Splicing of Steel Column.

When splices are made at the building, the superintendent should see that the riveted surfaces are painted before being put together, and that a sufficient number of bolts are used to hold the pieces together rigidly while being riveted.

The use of splice-plates for connecting columns is to be preferred to a connection of plate and angles; and if any part of the column section projects beyond the column section below, it should not be left unsupported, but should be given a bearing on a filling plate riveted to the lower column. The rivet holes in the column and splice-plate should fit perfectly so that "drifting," *i.e.*, straining the pieces together by means of a drift-pin, need not be resorted to; neither should heavy mauls be used to bring the members into position, but wooden mallets only. The finished rivet head should be clean and smooth without cracks or flaws, and the two heads should be concentric with the axis of the rivet. All rivets should be examined to see that they are tight and well formed.

Loose rivets are often tightened by simply calking around the head with a calking tool. This should be watched for and never be allowed to pass, as a rivet so treated possesses no working strength, being tightened simply by the contact of a thin edge against the steel members.

Grillage. The great loads which are concentrated at the bottom of the steel columns of a high building, will, in general, require a different treatment, to secure a firm foundation, from the stepped-up foundations of stone or concrete which we have already considered, as in Fig. 203. Of course it would be possible to extend the area of the succeeding steps of an ordinary pier foundation until it covered a sufficient footing; but this would in many cases be at a great expense and loss of room—two important factors in city buildings. To overcome this, and to provide adequate foundation within reasonable limits of depth and material, the use of steel beams for foundations has become general. This use of beams is known as grillage, and may be used for isolated bearings or for the bearing of continuous walls.

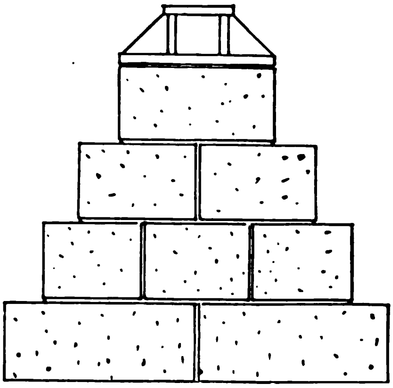

Fig. 203. Stone Footing and Base.

Foundations of this sort are usually prepared by laying down a bed of concrete from four inches to twelve inches in depth, and laying

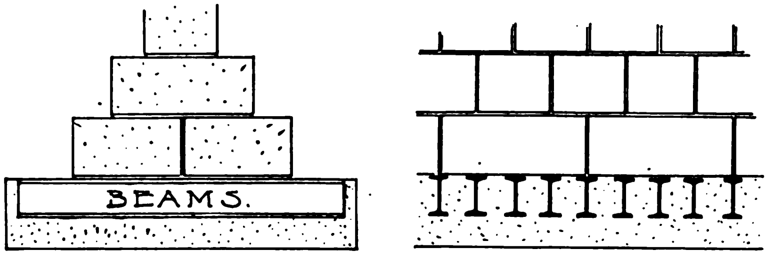

Fig. 204. Grillage under Wall.

upon this a series of steel beams. If a wall foundation, these beams are continued at a spacing varying from six to twenty-four inches along the wall, as in Fig. 204. If a column or pier foundation, the concrete and beams will be similarly put down in a square, of an area sufficient to sustain the estimated load, and these may be crossed by another or several tiers of beams laid at right angles, each series covering less and less of width until the footing is brought to the desired width to receive the base of the columns. (Fig. 205.) The distance apart of the beams will vary according to their length and the load to be borne, but should be at least enough to allow of filling and properly tamping the concrete between the beams. The whole is then finished flush with a bed of concrete. Sometimes the nature of the soil and the closeness of the supports will make it advisable to cover the whole area of the building with a thick bed of concrete, upon which the footings of beams or stone may be laid. Before laying the steel beams for grillage, they should be cleaned

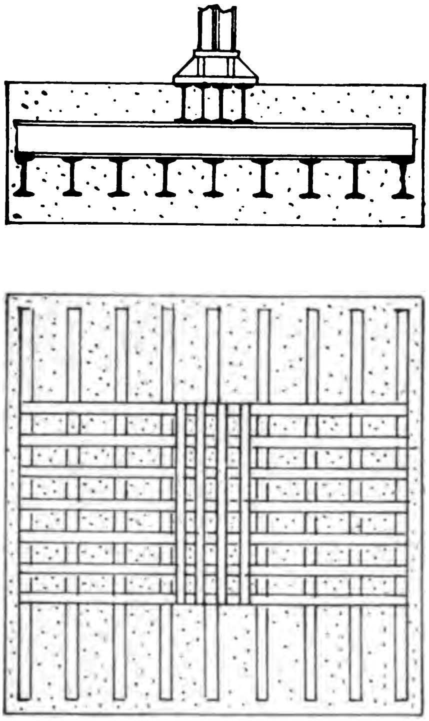

Fig. 205. Grillage under Column.

and coated with asphalt; and they should be examined before covering with concrete, and all defects found in the coating thoroughly covered.

Timber is sometimes used as a grillage, in connection with piling, by bolting a series of timbers to the tops of the piles, this timber crossed by succeeding series, and the top covered with a floor of thick planks to receive the masonry.

Caissons. Where the soil is too yielding or the necessary area is not available, foundations are sometimes carried to the bedrock. This is done by the use of caissons which are sunk through the soft material to the rock.

These caissons consist of a steel chamber, having the bottom edge extending below an air-tight floor, far enough to form a working chamber into which compressed air is forced, which keeps out the water and soft material, and enables the workmen to excavate and allow the caisson to sink to the bedrock. The excavated material is hoisted up through air-locked shafts, and the masonry of the foundation is built within the caisson, and helps to sink it down. When bedrock is reached, the working chamber is filled solid with concrete and a solid foundation is secured.

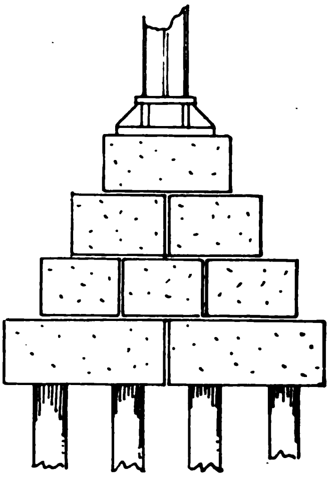
Fig. 206. Pile Foundation for Column.

This is called the *plenum* or *compressed air* process. Caissons are also sunk by the *vacuum* process, which consists in exhausting the air from the interior of the caisson, and allowing it to sink by the aid of the pressure of the atmosphere. By this process, the water is caused to flow under the lower edge of the caisson, loosening the soil and assisting the sinking of the caisson.

Pile foundations are also used as already described, sometimes in connection with a timber grillage, but generally with a foundation of concrete or stone. (Fig. 206.)

Cantilever Foundations. In buildings where, for any reason, it is not desirable or permissible to build foundations under an adjoining building, cantilever girders are used to support the columns at the party line. The principle of this construction is shown in Fig. 207, where a simple cantilever is shown bearing upon a beam foundation and secured to an interior column. By a proper adjustment of the loads, this construction may be made as rigid as if the wall columns had each its own footing, and complications often avoided.

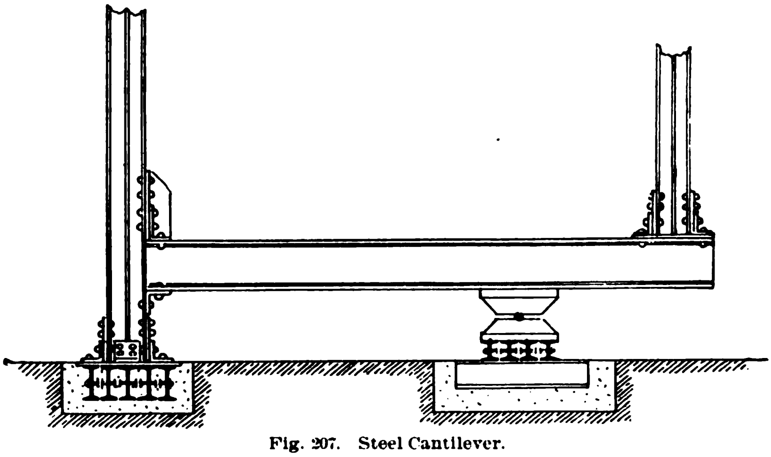

Fig. 207. Steel Cantilever.

Girders. Next in importance to the columns will come the steel girders which run between the columns, and support the floor beams. Where the load is too great for a single beam, two or more beams may be bolted together, as in Fig 208, or a girder may be built up of plates and angles, as in Fig. 209. These girders are connected to the columns by angles, varying in size and the number of rivets, according to the load on the girder; and if they bear upon the mason work, steel or iron bearing plates must be provided to distribute the load over a surface large enough to sustain it safely.

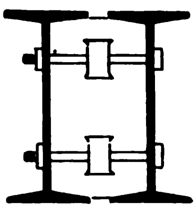

Fig. 208. Steel Beam Girder.

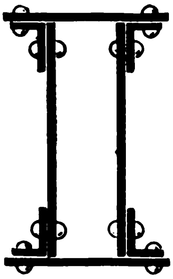

Fig. 209. Plate and Angle Girder.

Girders which consist of two or more I-beams should be connected by means of bolts and cast iron separators, Fig. 210. The office of these separators is to hold the beams in position, and cause them to act as one beam, and also to prevent lateral deflection under heavy loading.

The separator shown in Fig. 210 is the type in general use, and consists of a series of bolts running through a plate-shaped casting made to fit accurately to the outlines of the beams, and having a width equal to the desired space between the webs of the beams. Another form of separator consists of spool-shaped castings of the required length to fit between the webs of the beams through which the bolts are run. These do not form so rigid a girder as the plate separators, and are only used for light loads. (Fig. 211.)

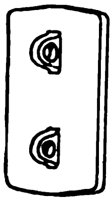

Fig. 210. Cast Iron Plate Separator.

Girder Connections. The connections of the girders with the columns are made by means of short pieces of angle iron riveted to the columns, above and below the girder, as in Fig. 212. The lower angle is made heavy and set so as to form a seat for the girder, and is reinforced by upright pieces of angle iron, also riveted to the column, if the load is very heavy. The upper angle serves to hold the top of the girder in place.

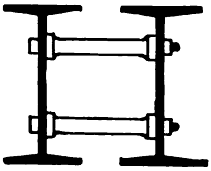

Fig. 211. Spool Separators.

Inspection. The workmanship of all riveting and splicing should be carefully watched, with especial attention paid to the fitting of the pieces. It is usual to punch the holes by machine and when several pieces are to be fitted it is almost impossible for the holes to fit over each other exactly. If the variation is not too great, it will generally be overcome by using a rivet smaller than the standard size, depending upon the hammering to make the metal fill the irregularities (which it will rarely do), so that the pieces are imperfectly joined. This should be guarded against, and the holes should be drilled or reamed out to receive rivets of the standard size.

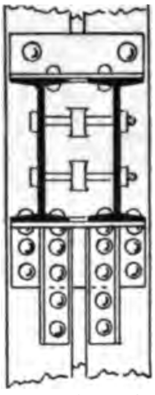

Fig. 212. Bearing of Beam Girder on Column.

Bolting is often substituted for riveting if no objection is made, but this is not good work, as there is danger of the bolts working loose, while riveting is absolutely rigid if properly done. Of course a certain amount of bolting will be necessary, and this should be watched to see that the bolts fit, and are long enough to receive the nuts properly.

When bolts are used on the sloping flanges of beams, bevelled washers should be used to give an even bearing.

Painting. Too much care cannot be taken in protecting columns and other steel work from corrosion. Where the members are painted, it is of great importance to see that no rust has formed under the paint, as the process will continue if once begun. If, however, the metal is perfectly clean, it will be protected as long as the paint remains whole. "Mill scale," a coating which is produced by the process of rolling the steel, must be removed before painting, or it will peel off and bring away the paint.

Cement Coating. Where the steel is completely encased in a cement or plaster fireproofing, there will be danger that the paint will decay in course of time and leave a minute crevice between the steel and the masonry which will allow rust to form; and for this reason it is a good plan to coat the carefully cleaned steel with a wash of Portland cement, which unites with the masonry and maintains a perfect contact with the steel. Under these conditions, no further rust or corrosion will take place.

Floor Construction. The size and spacing of the floor beams will depend upon the style of floor construction which may be adopted. The original fireproof floor consisted in spacing beams five or six feet apart, and turning a brick arch from flange to flange of the beams, as in Fig. 213. The space above the arch is filled with concrete up to about an inch above the beams, completely enclosing the steel; and screeds running parallel to the beams, bedded in the concrete, give a sufficient nailing for the floor boards. The ceiling underneath may be finished by simply plastering on the underside of the brick arch, or a level ceiling may be hung to the

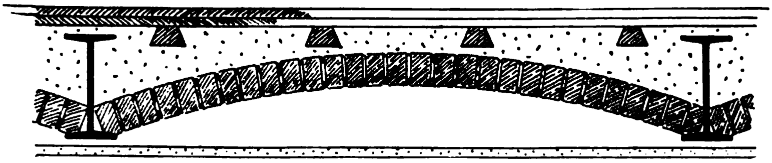

Fig. 213. Brick Floor Arch.

rough floor. As an arch of this shape will exert considerable thrust, this must be taken up by the use of tie rods ⅝-inch or ¾-inch in diameter, spaced along below the center line of beams at intervals of about six feet. This style of flooring will weigh about seventy pounds to the foot, and has been practically superseded by the lighter constructions employing terra-cotta arches or concrete.

Terra-Cotta Floor Arches. Hollow terra-cotta blocks, moulded in the form of a flat arch, are used to a large extent for fireproof floors, and are to be obtained in a variety of patterns and devices. These various patterns may be divided into two principal classes, the side method and the end method.

Side Method. The side method arch, where the blocks are laid with the webs parallel to the beams, Fig. 214, is the original form of terra-cotta floor arch, while the end method, where the blocks are laid end to end at right angles to the beams, is a later improvement, designed to present the full end section of the material to resist the great thrust of the arches. These side method arches are usually made of dense terra-cotta and may be obtained of various depth from six to fifteen inches, and they should be set with close joints, and be thoroughly cemented together. Specially moulded blocks, called "skewbacks," are made to fit the lower flanges of the beams and project about two inches below the beam, which is covered by a thin strip of tile. The space above the blocks is filled with a cinder concrete, in which bevelled wood strips are embedded for a nailing for the wooden floors.

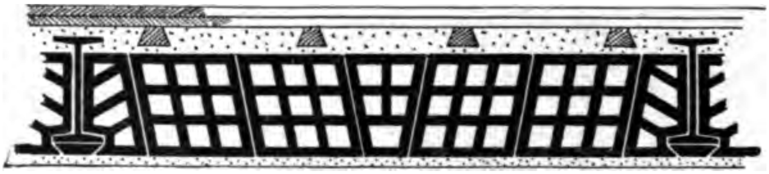

Fig. 214. Side Method Terra-Cotta Arch.

Side method arches are made to break joints endways, so as to give a bond; and they are usually strong enough for all ordinary floor loads. The joints in the blocks are generally made parallel to the sides of the key block, as this gives a uniform pattern, and so is less expensive than a radial jointing, though the latter would make a stronger arch, but on account of the expense of the different patterns, to make and adjust, it is little used.

End Method. In this method, the blocks are usually made of porous terra-cotta and are set end to end, giving greater resistance to the thrust by forming a series of continuous webs from beam to beam. (Fig. 215.) In this system, the blocks are usually set in continuous lines, not breaking joints. The jointing of these tiles must be done with great care, as the open ends do not give so good a surface for cementing as in the side method, and, the bearing on the beams being given by the thin webs, it is necessary that they should fit perfectly.

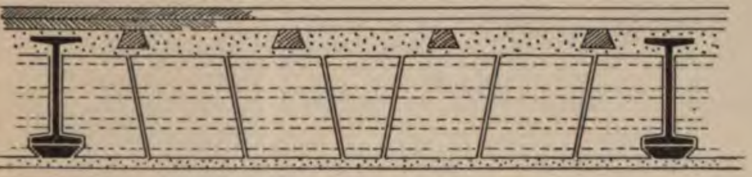

Fig. 215. End Method Terra-Cotta Arch.

For this reason a combination method is often used, shown in Fig. 216. This is done to gain the extra strength of the end blocks, and the better bearing of the flat skewbacks, so that the skewbacks are made with many webs and of small sections.

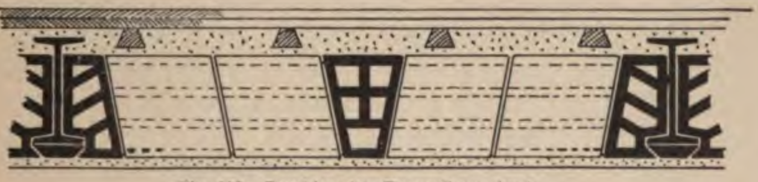

Fig. 216. Combination Terra-Cotta Arch.

Setting. Floor tiles of either pattern must be set upon plank centers which are hung from the beams, and should be crowned one-quarter of an inch in an arch of six feet. All joints must be close, and made with cement. The centering should be left in place until the cement is thoroughly set, which will require from twelve to thirty-six hours, according to the weather and the nature of the cement, and care must be taken that the freshly laid tiles are not too heavily loaded with materials until they are hard. If the arches are to be plastered upon for a ceiling, they must be kept clean, or bad stains are likely to appear. All holes or irregularities on the under side must be filled with cement mortar to give a proper surface for plastering. Where it is not required to have a flat ceiling, but strength is the main factor to be observed, segmental tile arches are often used. (Fig. 217.) These may be used, with a rise of an inch to the foot, up to twenty feet of span, and are employed to great extent in warehouse construction.

While the nature of floor tiles will not permit of a fine joint being made, they should be laid as closely as possible, especially the key blocks. Joints as great as a half-inch should not be permitted, and the tiles should be set in place by being "shoved" together as in brick laying. Unless the building is closed in, floor tiles cannot be laid in cold climates when there is danger of freezing and thawing, as the joints are liable to be affected to the extent of causing deflection if not more serious trouble.

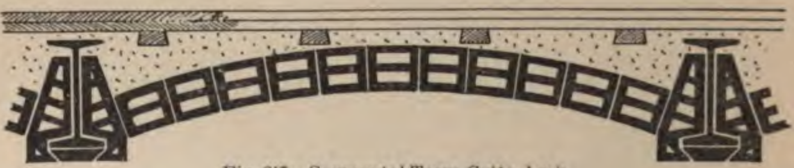
Fig. 217. Segmental Terra-Cotta Arch.

Floor arches are often tested by applying a heavy roller to the arches after the wood centers have been removed, and by dropping a heavy block of timber upon the arch, a two-inch bed of sand being previously spread over the tiles to prevent mechanical damage.

Concrete Floors. The use of concrete for floors has become an important factor in the construction of fireproof buildings. Concrete floors combine the qualities of strength and ease of manufacture with lightness and less expense than most of the hollow tile constructions. Concrete so used is generally found in combination with steel or iron in some form or other, to which it owes its tensile strength.

Concrete floors may be considered under two classes, one in which the concrete in combination with steel members forms the whole of the floor, and the other in which steel I-beams are set as for hollow tiles with the spaces filled with concrete upon wire cloth or expanded metal, or with these or strands of wire embedded, as tension members, in a plate or arch of concrete.

Of the first-named class of concrete floors, the Ransome patent is the best known. (Fig. 218.) This consists of the use of twisted square bars of steel running through the lower portion of the plate or beam to give the necessary tensile strength to the concrete; it has been used for spans up to thirty or forty feet without steel beams or girders. Another form of this floor consists of a lighter construction of concrete beams each with its twisted steel member, with a thin plate of concrete between. (Fig. 219.)

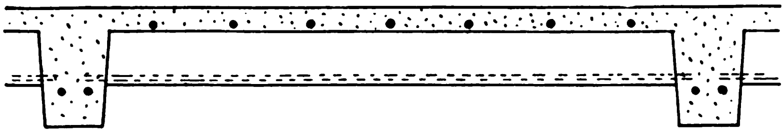

Fig. 218. Heavy Ransome Floor.

The other system of concrete floor construction differs from the hollow tile floor construction in the use of concrete for a filling between the beams instead of tiles; steel columns, girders and beams remaining the same as for the tile floors.

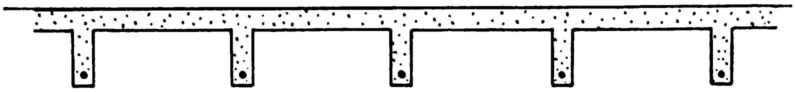

Fig. 219. Light Ransome Floor.

These floors are usually to be found in one of two forms—the flat plate of concrete lying between the beams or the segmental arch of concrete formed upon a center of metal lathing. Of the former system, the plate floor of the Expanded Metal Co. is a good example. (Fig. 220.) This floor consists of a plate of cinder concrete, from three to seven inches thick, in which is embedded a continuous sheet of expanded metal which is laid over the tops of the beams and is allowed

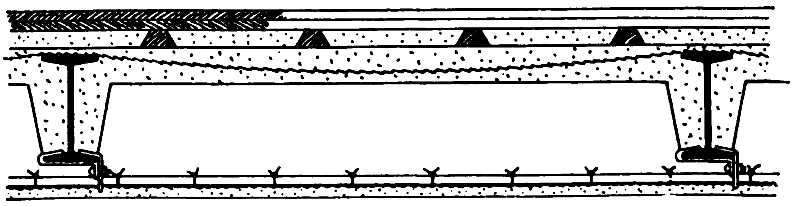

Fig. 220. Expanded Metal Floor.

to sag down between them a few inches. A flat centering of planks is hung with its surface a little below the sag of the metal, and a concrete of cinders and Portland cement is poured over and through the meshes of the expanded metal, and leveled off at an established height above the tops of the steel floor beams. Troughs are formed in the centering at each side of the floor beams which allows the concrete to completely enclose the beam.

On this plate of concrete, a wooden or cement floor may be laid in the usual manner, and a flat ceiling formed below by hanging stiffened metal to the beams; or the underside of the concrete plate may be plastered upon, forming a series of panels. These plates, of seven inches thickness have been used up to seventeen feet of span between the beams; and the average floor will weigh about thirty-five pounds to the square foot, and is about four inches thick.

Of the types of arched concrete floors, the Roebling patent is a fair example. (Fig. 221.) This construction consists of an arch of wire cloth stiffened with rods, which is sprung between the floor beams with more or less of a rise according to the spacing of the beams. Upon this arch, a concrete of Portland cement and sand is deposited, making, when set, a solid slab of concrete three inches or more in thickness at the top, with the haunches leveled up to the top of the arch. The most economical proportions for this floor have been found to be a basis of ten-inch beams, spaced according to the span and load, with an arch of three or four inches at the crown. This makes a very strong floor, and one not easily damaged, as it may be punctured by holes of any size without destroying the concrete arch, which is kept from shattering by the wire cloth. If a flat ceiling is required, it may be hung to the bottom of the beams of stiffened wire cloth and may be flat or panelled as desired. No centering is required with this floor, as the stiffened arches are bent to the

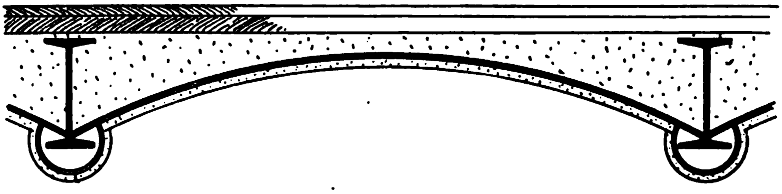

Fig. 221. Roebling Floor.

required curvature, and after being set in place, they possess enough strength to receive the load of concrete or the shock of any falling body. Being open to the air both above and below, the concrete sets quickly, two days being generally enough for safe use.

While these systems of floor construction are typical of the main features of all, they are not necessarily the best or only kinds, for many other systems, embodying variations of these features, are in constant use, some making use of twisted wire strands in place of expanded metal to support the concrete plate, others, steel bars of special pattern.

Selection. With so many styles of floor available, each possessing merits of its own, the architect will often be at a loss to decide upon a special system. Cost, which is an ever-present factor, will decide in some cases, and in others, local considerations may require particular methods. In the main, consideration should be given to lightness, strength, and fire-resisting qualities, as well as speed of erection and the skill of available workmen. Of the respective merits of the two rival systems of terra-cotta arches and concrete, much has been written, especially in regard to fire-resisting qualities, but the question of durability cannot be said to have been settled at the present time. For very high buildings one of the systems requiring the use of steel floor beams and girders will usually be adopted, and the beams spaced with reference to the load and the requirements of the floor construction; these beams may rest entirely on the top of the girders, but are usually framed flush with the top, allowing the girder to project if it is deeper than the beam. The beams are connected with the girder by means of angles riveted to the webs of the beam and girder. (Fig. 222.) Connections of the floor beams with the columns, which will occur where the spacing of the floor beams brings a beam opposite to a column, are made as described

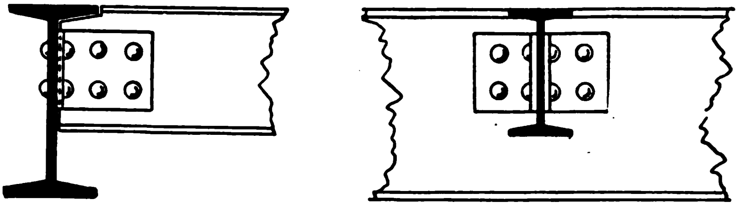

Fig. 222. Steel Beam Connection.

for light girders. The outside beams of the floor are sometimes allowed to run behind the exterior columns, forming no part of the exterior construction, but more often they are framed between the columns, and, in connection with other supports, help to carry the enclosing walls of the building. (Fig. 223.)

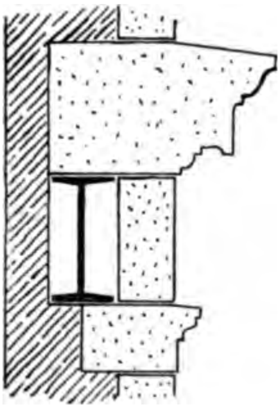

Fig. 223. Steel Beam in Wall.

Roof and Ceilings. As the roofs of high buildings are in general made with very little pitch, the same construction may be used here as for the floors, but a special treatment will be required to retain a level ceiling in the upper story. This is usually done by hanging steel T-bars at a level below the roof, and upon these a ceiling may be laid either of terra-cotta blocks to be plastered, as in Fig. 224, or of metal lathing, Fig. 225.

Exterior Walls. The construction of the exterior skeleton of a fireproof building will require special treatment according to the covering material to be used. While the adopted type of floors may be carried throughout one or several buildings, by a simple repetition of methods, the construction of the outside frame will vary with the different materials used in different buildings, or often in different portions of the same building.

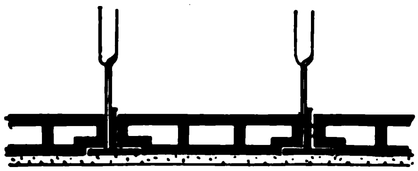

Fig. 224. Hanging of Terra-Cotta Ceiling.

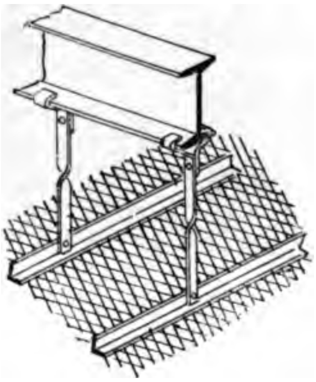

Fig. 225. Hanging of Wire Lath Ceiling.

In general, the weight of the exterior walls, especially above the first two stories, must be carried by the steel frame. The two or three lower stories, on the street side being largely glass area, the piers are often carried by the foundations below. These piers are sometimes of stone enclosing the steel columns, but brick or terra-cotta are used to great extent. For the upper stories, especially of a fireproof building, brick or terra-cotta are to be recommended, not only on account of the fire-resisting qualities, but also because of the ease with which they may be built around the skeleton frame.

In general, the exterior treatment of a building of skeleton construction will resolve itself into a series of piers, more or less marked in character, which enclose the vertical supports, the space between being to a great extent occupied by windows, with a horizontal piece of masonry separating the windows of each story and covering the floors.

The masonry enclosing the columns is generally supported by brackets or angles riveted to the columns, and the horizontal bands of masonry between the windows, called spandrels, are supported by beams of requisite size and shape, which run between the columns and are riveted to them.

The character of these supports will vary with the design of the building; but in general the inner beam will of necessity be of such form that it may also be used to support the floor construction. (Fig. 226.)

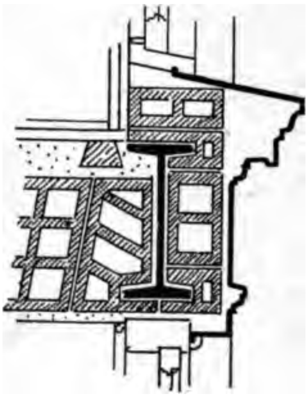
Fig. 226. Spandrel Beam.

Wind Pressure. A distinctive problem of high building construction is the provision for lateral resistance to wind pressure. Unless the building is more than four times its width in height, the effect of the wind pressure is not a serious consideration. The danger of overturning the building bodily is very remote, the chief danger being a tendency to shear the connections or twist and distort the frame. Sometimes the ordinary framing of the floors and columns will be sufficient, and in other cases special provision must be made. This is done by diagonal ties where the construction will allow, as shown in Fig. 227. When the spaces between the columns must be used for passage or for windows, knee braces and deep girders are used, as in Fig. 228, and portal bracing is sometimes adopted, but to no great extent. (Fig. 229.)

Inspection. Steel and iron members are inspected in the mill, the shop, and on the job. Mill inspection is to determine the quality of the steel, while shop inspection relates to the preparation of the members.

TYPES OF WIND BRACING

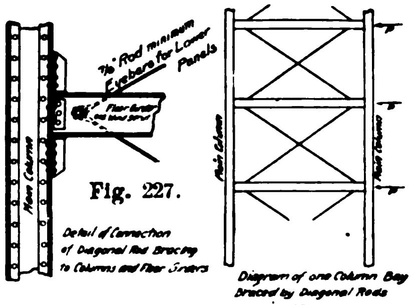

Fig. 227.

Detail of Connection of Diagonal Rod Bracing to Columns and Floor Girders

Diagram of one Column Bay Braced by Diagonal Rods to resist Wind Pressure

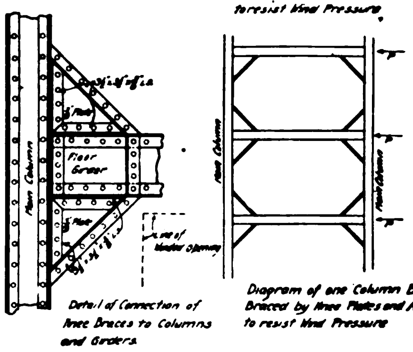

Fig. 228.

Detail of Connection of Knee Braces to Columns and Girders

Diagram of one Column Bay Braced by Knee Plates and Angles to resist Wind Pressure

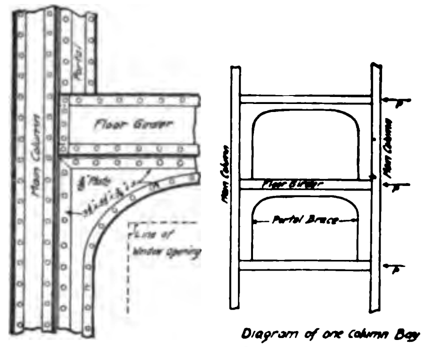

Diagram of one Column Bay Braced by Portals of Plates and Angles to resist Wind Pressure

Fig. 229.

It is necessary to see that the drawings are accurately followed, and the work properly assembled, that the quality of work is up to the standard, riveted tightly and accurately done. The members must be straight and free from twists or bends, punching sharp and true, with the holes in the different pieces exactly opposite. Column ends and all bearing surfaces true and at right angles to the axis. All portions not accessible after putting together must be painted before being assembled.

Terra-Cotta Covering. The adaptability of terra cotta to the exterior adornment and fireproofing of buildings is so great that its use has become general in all places where durability and resistance to heat are essential. The ornamental facings can not always be supported by direct bearing on the steel frame, and so a system of anchors and ties must be devised by which the separate blocks may be held in place.

For terra-cotta finish which has no great projection from the line of support, ties of one-quarter inch rods may be hooked into the ribs of the terra cotta and secured to the steel frame or the brick filling, as in Fig. 230, but when a greater projection is required, as for cornices, small beams or T-irons must be used, well built in or anchored to the main structure, as in Fig. 231. Exterior terra cotta as ordinarily finished is not affected by the atmospheric conditions which affect stone; but as the surfaces are liable to become warped in the baking, it will be necessary to see that no attempt is made to straighten bad pieces by chiselling, as this destroys the surface and exposes the softer interior to decay.

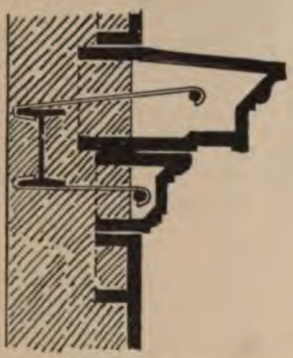

Fig. 230. Anchoring of Terra Cotta.

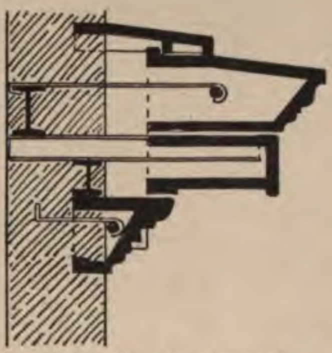

Fig. 231. Terra-Cotta Cornice.

Fireproofing. We have thus far considered the covering of the steel skeleton from the point of obtaining an available floor surface, and the necessary housing in by means of the exterior walls. While these elements are also made to serve their turn in protecting the frame from fire and the elements, further and complete protection from fire must be considered as of prime importance.

Columns. Especially is this true in the case of the columns, which necessarily sustain a great weight, and should therefore be adequately protected. Columns may be enclosed in brick, which should be not less than eight inches thick, or hollow terra-cotta tiles may be used, preferably in two layers, each not less than two inches thick and breaking joints. (Fig. 232.) Columns may also be protected by the use of metal lathing and plaster in one or two layers with an air space between. (Fig. 233.)

Girders. While the floor beams and flush girders are protected normally by the floor or ceiling construction, girders which drop below the floor must be given a special protection. This may be of porous terra-cotta blocks, shown in Fig. 234, or of metal lathing and plaster, Fig. 235.

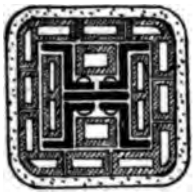

Fig. 232. Terra-Cotta Column Casing.

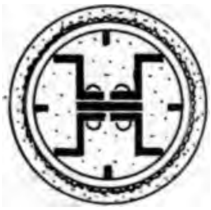

Fig. 233. Lath and Plaster Column Casing.

The makers of floor construction have each their own system of fireproofing of girders and columns and other exposed members, and, in general, the contractor for the floors will be given a contract for all the other fireproofing of the building.

Partitions. The partitions of fireproof buildings may be built of brick, terra-cotta, tiles, or plaster blocks, or of light iron studding with metal lathing and plaster. Brick partitions, to resist the passage of fire, must be at least twelve inches thick, and so are not generally used unless required for floor bearing also. With the column and girder construction which we have had under consideration, a lighter construction than brick is generally desired for partitions.

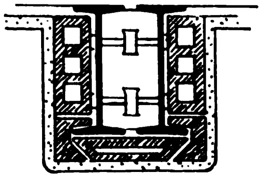

Fig. 234. Terra-Cotta Girder Casing.

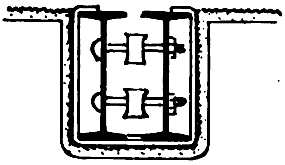

Fig. 235. Lath and Plaster Girder Casing.

Partition Blocks. Terra-cotta blocks, either of dense or porous terra cotta, make a very good partition; these are usually made four inches thick, and are of the same composition as the floor blocks. They are usually set with the hollows running horizontally, in order to obtain the flat surface for bedding, but where it is necessary to cut for vertical pipes, it is well to set a vertical line of blocks on end and clamp them to the flat tiles. All openings for doors and windows are framed with wooden studs (or with steel bars, if the door frames are of cast iron) to receive the frames and finish. (Fig. 236.) For thinner partitions, blocks of solid porous terra cotta two inches thick may be used, but they must be clamped or banded together. A patented partition may be obtained of thin terra-cotta plates reinforced by twisted steel wires run on either side of the plates and embedded in the plaster. Thin plates having plaster of Paris for a base, and clamped or banded with iron, are also used for partition blocks where extra lightness is required.

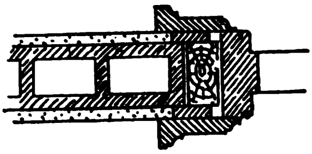
Fig. 236. Terra-Cotta Bloc Partition.

For all of these blocks, mortar composed of lime with a little cement should be used for setting, and the finished plaster surfaces are best when hard-setting plaster is used.

Metal Lath Partitions. For a saving of floor space, very thin partitions may be made by using small steel bars for studding; these are usually ¾-inch channel bars set vertically about a foot apart and turned at a right angle to be fastened top and bottom. On one side metal lathing is stretched and wired to the bars. This is plastered with a very heavy coat of hard plaster, which squeezes through the lathing and makes a good surface to receive the plaster of the other side side of the partition, forming, when completed, a solid wall of plaster and metal about 1½ inches thick. (Fig. 237.) It is necessary in this case to use a very hard setting plaster, as this gives the partition its stiffness. Special patented studs of sheet steel, made with prongs to hold the lathing, and of various depths, Fig. 238, are used in a similar manner. Door and window frames are set in these thin

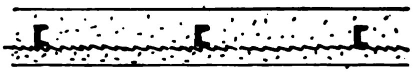
Fig. 237. Steel and Lath Partition.

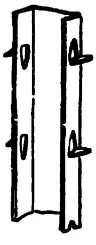
Fig. 238. Steel Stud.

partitions, by setting up a rough wooden frame to which the channel bar is screwed, as in Fig. 239, and for a nailing for chair rails, picture mouldings, and other finish, strips of wood are laced to the lathing, flush with the plastering before the plaster is applied. (Fig. 240.)

Metal Lathing. Metal lathing, which is of great importance, both for fireproofing, and the finish of fireproof buildings, may be obtained in a variety of patterns and devices. The original form of metal lathing was the common wire cloth, and this is still one of the principal forms in which metal lathing is found. Improvement in the manufacture of wire cloth for lathing may be found in the various means adopted for stiffening the cloth by rods or ribs of metal. These are attached to, or woven into, the lathing which is then known as "stiffened lathing."

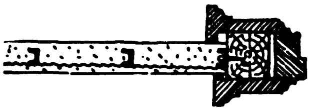

Fig. 239. Door Finish in Thin Partition.

A well-known form of stiffened lathing is the Clinton lath, which contains corrugated steel furring strips, attached to the cloth by metal clips and running across the roll every eight inches. These strips not only serve to stiffen the lathing, when stretched over furrings, but, if the lathing is applied directly to a plain surface, such as planking or brick walls, the stiffening keeps the lathing away, and allows room for the clinch of the plaster.

The Roebling stiffened lathing contains V-shaped ribs of various depth, which are woven into the cloth at 7½-inch intervals. These ribs serve for a furring, and are made from ⅜ to 1½ inches in depth. For special uses, ribs of ¼-inch steel rods are used instead of the V-shaped steel. Wire cloth for lathing is run in a variety of meshes; 3 × 3 and 2½ × 2½ to the inch being the common mesh, and it may be obtained plain, painted or galvanized; painted lathing being very satisfactory, and more generally used than any other kind.

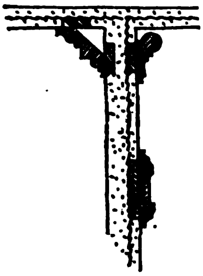

Fig. 240. Wooden Furring in Thin Partition.

Expanded Metal Lathing. This form of lathing is made from strips of thin and tough sheet steel, which are cut at regular intervals and then "expanded" by being wrenched or pushed into open meshes, greater or less, as the cuts are made longer or shorter. This expanding also turns the metal on edge, making a flat and stiff sheet of lathing much larger than the original piece of metal. (Fig. 241.) Having a degree of stiffness, this lathing does not require stretching, and it is used extensively for wrapping steel beams or columns for fireproofing or finishing, for thin partitions, and for concrete floors.

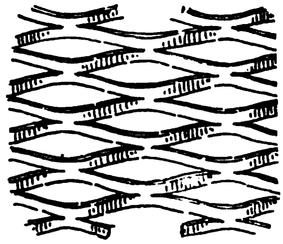
Fig. 241. Expanded Metal Lathing.

An objection is sometimes made to wire or expanded metal laths, that they require an excessive amount of plaster for ordinary uses. This may be overcome, when feasible, by the use of the Bostwick sheet metal lath, shown in Fig. 242. This is made from sheet steel by punching out loops at regular intervals. In this, and many other forms of sheet metal lathing, the surface is corrugated, besides being punched, to give stiffness and to keep the lathing away from the surface to which it is applied. Sheet metal lathing is easily adapted to the forming of coves or round corners, but for fireproofing the open lathing, requiring a greater amount of plaster, with the metal more thoroughly imbedded, is to be preferred.

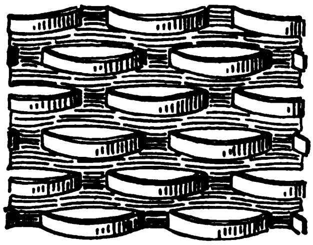
Fig 242. Bostwick Lath.

Hard Plaster. The use of the so-called "hard plaster," for the finishing of business and public buildings, is to be advised wherever the slight increase in expense can be borne. For business blocks, the saving in time will usually more than cover the extra cost, and for schools or hospitals the harder and cleaner surface is to be desired.

These plasters are made, some of natural cement, and others by chemical preparation, and when dry they form a clean hard surface. The natural cement plaster is slower of setting, but of greater adhesiveness, but the chemical or patented plasters set very quickly and give good results when properly used. The cement plasters are sold as a cement only and the sand is applied when the mortar is mixed.

For use on lathing, "fibered cement" should be obtained, but for plastering on brickwork or terra cotta, cement without fiber may be used. These cements are known as Acme, Agatite, or Royal cement.

The best known of the chemically prepared plasters are King's Windsor, Adamant, and Rock plaster. These are sold with the fiber and sand all combined and ready to use, by mixing with water in the prescribed proportion. Full instructions for use are furnished by the manufacturers, and these directions should be absolutely followed, as they are the result of careful preparation and long experience. These plasters can be finished with a white coat as upon lime mortar, and this will be necessary if a white finish is desired upon the natural cement plasters, as they are gray in color.

Keene's Cement. For a very hard finish for bases, dadoes, columns, etc., or for any plaster work where a polish is required, Keene's cement, an English preparation, is generally used; but some of the best grades of American manufacture are said to be as hard and of less expense than the imported cement. Keene's cement is sold in two grades, coarse and superfine, either of which will make a hard finish, but superfine should be used where a polish is to be desired.

Scagliola. For interior finish, scagliola, or imitation marble, is used to some extent for columns, dadoes, etc. This is made upon a ground of lime mortar containing a large proportion of lime and hair. When this groundwork is thoroughly dry, it is covered with a coat of Keene's cement on plaster of Paris, which is mixed with the various colors and polished until it resembles marble. For flat surfaces, this is sometimes made in slabs upon plate glass. Silk threads, dipped in a thin solution of plaster of Paris, colored to imitate the veining, are arranged upon the glass, and the body color put on over them. The silk threads are then withdrawn, and a backing of plaster of Paris and cement, with a webbing of canvas, is spread to the desired thickness. The slabs, when hard and dry, may be taken from the glass and polished in the same manner as genuine marble. When scagliola is skillfully made and polished, its resemblance to genuine marble is almost perfect.

Window Frames. It has been the custom to make the window frames and sashes of a fireproof building of wood, in the same manner as for ordinary city buildings, depending upon shutters of tinned wood or metal construction for protection from external fires. Later developments of fireproof construction, and the disastrous effects of fires in the vicinity of many so-called fireproof buildings, have led to the growing use of metal for all external parts. Several patented forms of metal frames and sashes have been introduced, among which are some made of wood and covered with metal, as shown in Fig. 243, and others entirely of metal, as in Fig. 244. These windows are arranged to close automatically, and, when glazed with wire glass or with small lights of prismatic glass in metal bars, form a filling which is acceptable to most of the insurance exchanges as fireproof.

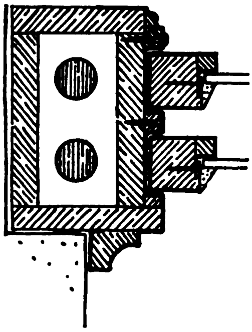

Fig. 243. Fireproof Window.

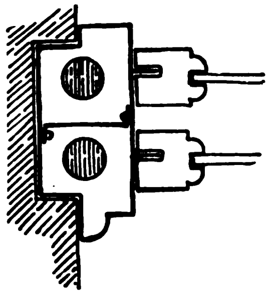

Fig. 244. Fireproof Window.

This form of glazing is of course not adaptable to show windows and large store lights, but as the upper stories are subjected to the greater danger from fire in adjoining buildings, this defect is not serious.

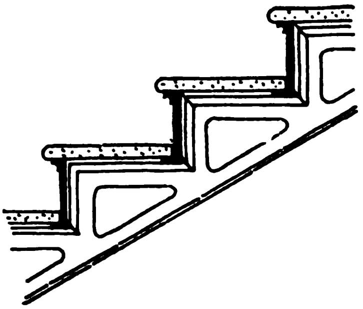

Fig. 245. Cast-iron Stair Stringers and Finish.

Interior Finish. While wood is in general use for interior finishing, it is now possible to obtain inside doors and finish made or covered with metal. These doors are usually made of thin sheet metal over a core of pine, and they may be plain or moulded to resemble wooden doors.

Stairs. The stairs of a high building are rarely used above the lower stories, except for emergency, or at times when the elevators are not running; so it is the custom to make staircases simple in design and construction, except perhaps the lower flights, which are often made of marble or of ornamental iron or steel. A simple form of stair construction, and one in general use, consists of a plain cast-iron stringer with cast-iron riser and marble or mosaic treads. (Fig. 245.) The outside stringer may be more or less ornamental, and the soffit or under side of the flight should be neat and presentable, as it will be in close view when passing down the flight underneath. The stairs should be arranged so that the stringers will not be too long to be of cast iron, if desired; but sometimes a steel beam or channel is used with the forming for the steps bolted on, as in Fig. 246. In either case, the bottom and top of the stringers must be securely fastened to the floor beams. Sometimes the stairs will be laid out to enclose one or more elevators in the well room, and in this case a support for the stringers may be obtained by the corner posts of the elevator enclosure, which, in turn, will be strengthened by the lateral support of the stairs.

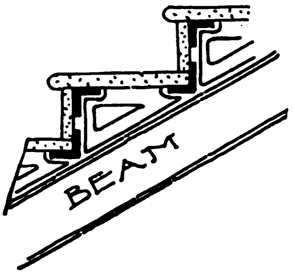

Fig. 246. Beam Stair Stringer and Finish.

PIPES AND CONDUITS.

The running of pipes and conduits in fireproof buildings brings forward a system, differing in some essentials from the ordinary piping of buildings with wooden floors. In the first place, less cutting of material is available to make spaces for pipes, and so more careful consideration must be given to this matter in the early stages of the construction; and again the necessity of leaving no continuous channels or connection from one floor to another, which would allow the passage of fire, will require that the pipes be run in exposed situations as far as possible, so that the floor material may be filled closely around each pipe. This is a point that the superintendent will need to keep constantly in mind and be sure that it is done in every case.

Plumbing Pipes. The main soil, waste and vent pipes should be of wrought iron with screw joints, not only on account of the great weight of the high stacks of pipes, but because the expansion and contraction of the great height of pipe would destroy the lead caulking usual with cast-iron pipes. The pipes must be securely fastened to the solid frame of the building, and all joints well screwed together with ample chance for expansion. Brass supply pipes should be used throughout, nickeled or bronzed to taste when showing. As the pipes will all show, the soil and waste pipes will need to be smooth and well put together so that when bronzed or finished they will not be unsightly.

Gas and Electric Piping. Before the plastering is begun, the pipes for gas and the conduits for electric wires, must be run. These, being small, may be concealed, if desired, although the idea of exposing gas piping is becoming more in vogue, especially where thin partitions are used. When hollow blocks are used for the partitions it is customary to channel them for the rising pipes and conduits; while the horizontal pipes are usually bedded in the concrete filling over the floor construction. (Fig. 247.) Sometimes the horizontal pipes are run under the floor beams, the suspended ceiling being dropped low enough to allow free circulation for the pipes. Sometimes the pipes are run between the floor beams; but if the girders are framed flush, it will be necessary to punch holes in them, and lateral branches cannot be easily managed. Where no partitions are available in which to run vertical pipes, as often occurs in the lower stories, the casing of the steel columns may be enlarged, so as to allow of pipes being run up, but if this is done, a separate flue outside the column casing, as in Fig. 248, should be made, as the insertion of pipes or conduits directly into the column casing destroys its fireproof value to a large extent, beside subjecting the steel to the action of injurious gases.

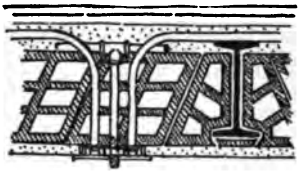

Fig. 247. Electric outlet in ceiling.

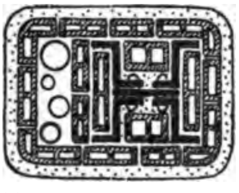

Fig. 248. Pipes in Column Casing.

Heating Pipes. The pipes for heating the building will in general be run outside of the plaster, and will be bronzed to match the radiators and other exposed piping. The number and size of the pipes will depend upon the system of heating used. For a large building, the heating is generally put in charge of an engineer who devises a system subject to the approval of the architect, but some stated conditions will in general be found to apply to most buildings.

Heating System. In almost every large building, the exhaust steam from the engines necessary to run elevators and dynamos will suffice to heat the rooms, and this may be done in two ways. The exhaust steam may be forced or drawn through the radiators and transmit heat directly to the building, or it may be carried to a coil in a water tank in the basement, heating the water, and causing it to circulate through the pipes and radiators instead of the steam. By the latter method a more uniform distribution of heat will be obtained and any danger of back pressure on the engines will be avoided. This tank must be placed low enough to prevent any backing up of the water to the engine, and the circulation of hot water to the radiators may be laid out in a manner similar to the circulation from an ordinary heater, which has been previously described. The greater height and multiplication of radiators will require a much more complicated system of piping, but the main features will be the same. The most effective service will of course be obtained by putting as few radiators as possible on a direct circulation, but as this adds very much to the expense it is quite usual to run one or two large mains up to the top story and from a horizontal run in this story, to bring down the hot water to supply the radiators, continuing this pipe to the heater. This of course gives a better supply to the top stories than the lower ones, so the difference is made up by putting larger radiators in the lower stories.

The first story, being subjected to more glass exposure and cold from the doors, is sometimes supplied directly from the risers, and the discharge returned by separate pipes to the tank, while the other radiators, being supplied by a descending current, are supplied and discharged into the same pipe without interfering with the circulation. The system of indirect steam heating by a fan is often to be preferred for the large stores, or corporation offices, which usually occupy the lower story of a city block. For the heating of the smaller upper offices it is a good plan to drop a riser, as described, between each pair of windows, placing a small radiator in front of each window. These may be supplied with fresh air by means of sash ventilators or other fresh air inlets, or they may warm the room by direct radiation.

Lavatory Fittings. The plumbing fixtures of an office building need not differ to a great extent from house fittings, and the same principles of construction will apply. The fixtures will consist mainly of bowls or sinks and water closets and urinals. All fittings should be strong and of simple construction, easily accessible for repairs or cleaning. The use of wood for partitions or floors should be avoided when possible, marble slabs and marble, mosaic, or tile floors being preferable. Water closets should be placed in well ventilated ranges, with partitions of marble, and slatted doors kept up a foot from the floor. All hinges, fastenings, and metal fixtures should be of nickel-plated brass. Urinals of the ventilated hood pattern are to be preferred and these should have a dished floor slab of ample dimension.

Inside Finish. While wood is used to a large extent for the inside finish of fireproof buildings, the use of incombustible material is increasing. The forms of metal sash construction which we have described for outside windows may all be adapted to interior uses, and, with metal doors and frames, and marble or mosaic floors, each office may be made practically fireproof in itself. Doors with sheet metal covering are often used, and these may be set in cast-iron frames made with rebates or channels to receive the plaster or block partitions. (Fig. 249.) The doors are sometimes made of hollow metal, but more often of a pine core completely encased in sheet metal. (Fig. 250.)

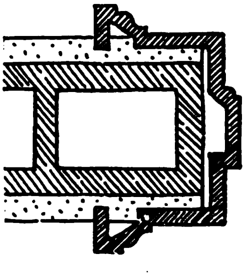

Fig. 249. Cast-iron Door Jamb.

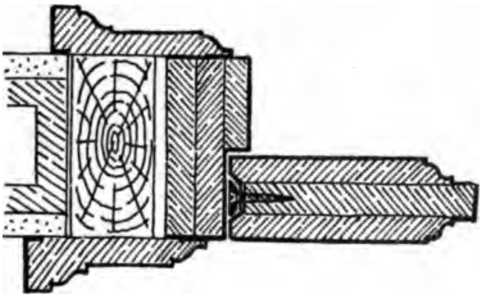

Fig. 250. Sheet Metal Door and Finish.

PAINTING.

With the hanging of the doors and the setting of the hardware, the mechanical processes will be completed, and the building will be turned over to the painters for finishing.

Here the methods and materials will differ little from ordinary practice [illegible] the greater amount of woodwork and the [illegible] of finished metal and plaster work to be treated. [illegible] which is to be painted must be perfectly [illegible] Rust spots may be removed by [illegible] and the ornamental work should be thoroughly cleaned, and the paint carefully applied in thin coats so as not to [illegible] the pattern.

Plaster [illegible] to be painted must be free from flaws or cracks, and both the plaster and the wall behind it must be thoroughly dry. Plaster [illegible] be brushed over just before painting, and the surface [illegible] primed.

Completion. With the departure of the painters, it will remain only to see that the building is thoroughly cleaned from top to bottom, and all paint spots removed from glass, marble, and all other exposed material.

The superintendent should carefully review all notes and memoranda made during the progress of the work, and be prepared to furnish a complete and detailed account of proceedings, including a record of all orders received and given, materials rejected, and the defects which warranted their rejection.

A diary should be kept, recording the state of the weather, the number of men of the different trades employed, the progress from day to day, a record of accidents, and any other data which would be likely to prove of value or interest. A record of this sort will not only be of possible value to the owner, but will contain data which may be of great value to the superintendent as a guide for future operations.

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